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WATER SUPPLY, SEWAGE and INDUSTRIAL WASTE TREATMENT

BY

WAR UTILITIES SUB-COMMITTEE

Technical Industrial Intelligence Committee

FIELD INFORMATION AGENCY, TECHNICAL

REPORT

ON

WATER SUPPLY, SEWAGE, AND WASTE TREATMENT

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ACKNOWLEDGEMENTS

The War Utilities Sub-Committee TIIC (U. S.) was organized under the chairmanship of Edward Falck, Director, Office of War Utilities, War Production Board. William J. Baily, also of W.P.B., served as executive secretary and negotiated the organization of the U. S. field teams. Cornelius W. DeForest served as London representative of the committee from March 14 until his return to the United States July 15, 1945. He organized the work for the field teams on the Continent and had general direction of their operations. He was succeeded by Col. Walker Cisler of the Production Control Branch, Public Utilities Section G-4, who was assisted by Arthur E. Gorman, one of the members of the war utilities field team.

The field teams are indebted to Col. Cisler and his staff for the cooperation secured in connection with their field activities and also to various members of the Allied Military Forces whose cooperation made it possible to visit various areas of occupied Germany in carrying out assignments.

REPORT

ON

WATER SUPPLY, SEWAGE and INDUSTRIAL WASTE TREATMENT

INTRODUCTION

In conformance with the expressed aims of the Combined Intelligence Objectives Subcommittee the following report on water supply, sewage and industrial waste treatment as observed in Germany has been prepared.

The initial field investigating team consisted of: Arthur E. Gorman representing the War Utilities Subcommittee, and Anthony J. Fischer and Arthur V. Sheridan representing the Safety and Technical Subcommittee of TIIC (U.S.). This group was later supplemented by Lt. Col. Joseph J. Gilbert, SnC., representing CIOS and the Surgeon General's Office, U. S. Army, and he was assisted by Maj. Myron W. Tatlock and Lt. Harold P. Pfreimer, both affiliated with Allied Military Government in Germany. Major Tatlock collaborated in the preparation and assembly of the final reports.

The report represents the combined effort of those whose names are given above and sets forth in summary form a concensus concerning the subjects under investigation. It also contains a somewhat detailed account of the more important observations and recordings upon which the summaries are predicated, together with a number of exhibits and supporting data.

Approximately three months were consumed in investigating and reporting. With the restricted facilities available, only such locations and sources of information as were known or uncovered could be studied and evaluated. These are referred to in the text as targets and include geographical regions, municipalities, public and private utilities, manufacturing plants and products, public officials, operating personnel, engineers and chemists.

The report contains data, selected from representative sections of Germany west of Berlin. For the

purpose of facilitating review it is divided into three parts; Section A dealing with water supply; Section B, dealing with sewage treatment; and Section C, dealing with the treatment of industrial waste. Because of the limited amount of published material outside of the Ruhr concerning water supply practice in Germany, as compared with the more frequent recordings of sewage and waste treatment practices in that country, the former subject is discussed in relatively more detail.

Considerable useful information, not incorporated in the text of the report because of the lack of dependable translation facilities, was found in limited publications and original records. In many instances, essential data incident to the design and operation of specific targets were not available because of loss or destruction during the war.

Discussion of administrative or economic controls relevant to the subjects under consideration has not been attempted. Lack of time, together with an appreciation of fundamental differences in natural resources as well as in the political and economic structures of Germany and the United States, were the reasons for this omission.

REPORT

ON

WATER SUPPLY, SEWAGE, and INDUSTRIAL WASTE TREATMENT

IN GERMANY

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SECTION A

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SECTION A

WATER SUPPLIES

This report deals with observations on the design, operation and maintenance of plant and equipment used in providing water supply in Germany in cities and large industries west of Berlin. Specifically, it includes reports on various aspects of water supply in 14 public systems in large cities of Germany and two large industrial plants specializing in war production. In addition, it includes reports of consultation with engineers, chemists, and representatives of equipment manufacturers primarily interested in water works practice. While this report does not deal with water supply to small communities, the findings are considered to be representative of German water works practice immediately prior to and during the war.

The investigation confirms reports that German water works are well designed and are operated under good technical supervision. Items of special interest pertain primarily to the development of sources of supply, especially ground water; treatment and purification methods; and facilities for the collection and storage of water.

SOURCES OF SUPPLY

The sources of water supply for public and private systems in Germany vary depending on location. The country has an abundance of underground water; wells, springs or infiltration galleries. In excess of 75 percent of the public supplies are from such sources. The well water supplies often contain objectionable amounts of free carbondioxide, iron, and manganese, requiring treatment for their removal or reduction. Treatment for softening is less frequent in the case of public water systems than in those used for industrial purposes. Surface supplies from rivers or impounding reservoirs are usually filtered.

Wells

Wells for obtaining ground water are both shallow and deep, with some of intermediate depths. Shallow wells predominate, ranging from 10 to 15 meters (approximately 40 to 60 feet). They are usually dug by special equipment, the space between the excavated section and the screen and discharge pipe being filled with various sizes of gravel, the largest size being near the screen. Spacing of wells, depending on underground soil conditions, the size and rated

capacity of the well, ranges from 10 to several hundred meters. The more common spacing of shallow wells is between 15 and 30 meters (approximately 60-120 feet).

Screens of copper alloys are most prevalent and are preferred by German water works engineers. Since the war, however, many well screens have been constructed of cast iron and steel covered by hard or soft rubber, a fluted and glazed ceramic material, and of oak wood. Screen openings are circular or slotted, the latter being most common. Sizes vary depending on local conditions.

Shallow wells are in most cases connected in series by a pipe line which delivers the ground water to a central collecting well from which it is pumped. The diameter of these lines varies, depending on the capacity of the wells. Delivery from the wells is by gravity or a flow induced by maintaining a vacuum in the collecting system; the negative head used is determined by the rate of delivery desired. In one plant visited, the air lift principal was used to remove water. Concrete or brick basins are as a rule built around the upper portion of series wells, providing access to valves in the well discharge and collecting lines. Such basins are covered, sealed, and kept locked.

Deep wells, usually operated as units, vary in depth from 100 to 450 meters. They are usually cased, in part or whole, with steel casings. Pumps used for deep wells are the series impellor type, or the submerged pump and motor type.

Infiltration Galleries

Infiltration galleries are of three types: (1) galleries constructed in rock under hills or mountains to intercept underground water flow, as in Munich; (2) galleries constructed parallel to river beds or between artificial surface filters for recharging ground water, as in the Ruhr area; and (3) galleries constructed in artificially built collecting areas where there is outcropping of water in a valley between hills or mountains, as at the Ranna Plant supplying Nürnberg. In the first case, the galleries are of concrete, stone, or brick, with openings thru the walls to permit entrance of the outside water. They are usually semi-elliptical in shape and vary in size up to 2.0 m. equivalent diameter. The other type galleries are usually constructed of reinforced concrete, steel, or cast iron pipe with holes or slots of various sizes in the walls. Flow is by gravity or

by induced negative head to a central well or collecting chamber equipped with pumping and measuring equipment. The depth of these galleries depends on local conditions; those in the Ruhr area averaging 10 meters, or 33 feet, and those at Ranna 8 meters, (26) feet deep.

Impounded Surface Supplies

Typical impounded surface sources are the Haspetalsperre near the city of Hagen; the Sösetalsperre and Eckertalsperre of the Hartz Mountain Water District, supplying the city of Bremen as well as cities and villages in the Province of Hannover; and the Dreilagerbachtalsperre and Kalltasperre of the organization supplying cities, villages and industries in the vicinity of Aachen. The watersheds are usually owned in part or whole by the operating agencies and are not exposed to serious surface contamination. Algae growths in the reservoirs and occasional turbidity make it necessary to filter the water from such sources. Where conditions are favorable hydro-electric power plants have been built in connection with these supply sources.

River Supplies

Where river water is used it is usually filtered, with or without coagulation and settling; at Bremen it is settled and filtered in slow sand filters; at the Buna Werke at Schkopau, it is settled and filtered in rapid sand filters, while at the munitions plant at Ebenhausen, river water was coagulated but not settled, and filtered in pressure filters. Where lake water is used, it is settled and filtered, usually without the use of coagulants.

DISTRIBUTION

German water works use cast iron, steel reinforced concrete, brick alone, or brick and concrete distribution lines. Sizes vary from 0.3 to 2.0 m in effective diameter. Pressure lines are usually of cast iron, steel or reinforced concrete. Gravity lines are frequently of three ring brick and concrete sections, built in place. Tunnels are both lined and unlined. Siphons are usually of steel, cast iron or reinforced concrete.

PUMPING

Pumping facilities in German water works are of all types. The pumping stations are well laid out and operated and maintenance is generally good. Recording equipment, modern in all respects, is generally provided in the larger stations for control and operation. Much new equipment has been installed in recent years to provide reserve units against the contingencies of war, and special equipment and construction to protect power and pumping units against bombing or other war damage are common. These usually consist of reinforced concrete or structural steel enclosures around individual units or groups of equipment and heavily reinforced concrete bunkers were provided both inside and outside the stations for operators on duty.

Low lift pumping stations continue to use or hold in reserve for standby service a surprising number of old vertical and horizontal reciprocating low pressure steam pumps. Crank and fly wheel engines and belt drives, both leather and metal, with gear reducers are not at all unusual. There are also many plants using modern electric motor and steam turbine driven centrifugal pumps. High pressure pumping is usually done by electric motors or steam turbine centrifugal pumps.

Auxiliary equipment in the pumping stations was both steam and electric and standby diesel engine driven generators were provided in many plants as protection against disrupted electric power. There were very few gasoline engine driven pumps in use except on small emergency units.

TREATMENT

Since German ground waters often contain objectionable amounts of free carbon dioxide, dissolved iron and manganese, they must be treated for domestic and industrial use.

CO_2 Removal

This is done to prevent corrosion of pipes and the solution of lead in service pipes. In 1930, Leipzig experienced an outbreak of lead poisoning, including50 serious and 200 minor cases because of high percentage free carbon dioxide in the water from its Carnitz plant. In most large plants the water is treated with hydrated lime using the Bücher process, in which a milk of lime solution is prepared and pumped into large tanks through which all or part of the water passes. The equipment used applies the lime in proportion to both the flow and CO_2 removal desired and the precipitated carbonates resulting from the treatment are discharged intermittantly from the treating tanks.

At the Buna Werke plant in Schkopau, carbon dioxide was removed from the drinking water in cone shaped tanks - "spiraction" - charged with quartz and marble dust. The milk of lime solution was pumped into the tank and as a result of the reaction with the water calcium carbonate built up on these media until beads were formed. When they reached a certain size they were removed and the tank was recharged with the fine dust.

Iron Removal

It is customary in Germany to remove iron from public water supplies to less than .05 ppm. This is accomplished by filtration in slow, rapid sand, or pressure filters after aeration to oxidize the iron in solution. The most common method of aeration is by gravity fall from an elevated collecting basin through distributor pipes onto specially stacked bricks. Usually the aerated water is settled in receiving tanks under the aerators or in other tanks prior to filtration. The settling periods vary from 1.0 to 2.0 hours. By this method up to 75 percent of the iron is removed prior to filtration.

In advance of downflow over brick aerators at Hagen the water is aerated by cascading downward from the inflow manifolds over staggered planks and into the distributor pans. In a small suburban plant near Leipzig the water is dropped through distributing pipes seven feet to splash plates and is collected in pans and redistributed over the brick aerators by a series of pipes having holes in the bottom.

At Kassel air is pumped into the well water for iron removal prior to filtration in a pressure filter using fine marble sand as a filter medium. Iron is also removed in double pressure filters; one unit with a coarse filter medium and upflow of the water serves as a contact chamber, the other with downflow through finer material is used to remove the flocculated iron not retained in the contact chamber. Both units are cleaned by backwashing.

Manganese Removal

The use of pressure and rapid sand filters with a calcined dolomite filter media consisting of magnesium oxide, and magnesium and calcium carbonate is common. This filter medium, mixed in a natural state in Russia, must be replaced about every 6 to 8 years. Treatment to precipitate magnesium hydroxide by excess lime treatment was not used in any plant visited.

Softening

The waters of German plants visited vary in hardness from 10-20 ppm in the surface water to 500 ppm in well and river water at Stuttgart. The range of hardness for most of the shallow well waters is between 100 and 200 ppm. No treatment plants for softening were seen except those for boiler feed and special processing at industrial plants where Zeolite softeners were used.

Filtration

With the exception of water collected from infiltration galleries most water supplies in the German cities visited were being filtered. Operation and maintenance of these plants is generally good. The use of coagulants is the exception rather than the rule. Several plants which normally do not coagulate the water prior to filtration use aluminum sulphate when the raw water is highly turbid. Only one plant used any other coagulant. This was at a munitions plant in Ebenhausen where river water used for industrial purposes was coagulated with ferric chloride. At the same plant well water for domestic use was treated with aluminum sulphate.

Chemical storage and mixing practices in Germany are similar to those in the U.S. Although handling in bulk was more by manual than with mechanical equipment, cranes and conveyors were seen, but no vacuum systems were observed. Batch mixing is common. Mechanical stirring is general. Measurement is both gravimetric and volumetric. Rotometers are used in many plants. Duplicate equipment is not unusual. Rate of application in proportion to flow is both automatic and manual. Solution tanks are of steel, concrete and wood with linings of hard and soft rubber, porcelain and wood. Chemical piping is made of lead, bakelite, plastics, hard rubber and steel with rubber or porcelain linings. Chemical feed pumps are lined with bakelite and plastic. At the Osterode plant in the Hartz Mountains, the chemical solution is filtered before being pumped to control devises.

Slow mixing, 10-20 minutes by vertical mechanical stirrers, was used in the BAMAG type rapid sand filter plant at the Hagen Hengstey plant. Mixing was accomplished at the Hagen Haspetalsperre plant of the WABAG type by the hydraulic pump principle.

Around-the-end mixers were used at the Hartz Mt. Osterode plant.

German practice leans toward the use of pressure roughing filters in lieu of settling basins prior to rapid sand filtration, but settling basins are usually provided with settling time varying from one to two hours where filtration is for iron removal. Settling basins are used in advance of slow sand filters at Bremen where Weser River water, subject to high turbidities, is treated without the use of coagulants. Tanks with a settling period of one hour preceded rapid sand filtration at the Buna Werke plant in Shokopau. Settling basins are of reinforced concrete and brick construction with and without covers. Mechanical scraping mechanisms for removal of settling basin sludges were seen at but one plant; the Buna Werke at Schkopau.

Slow sand filters seen were all covered excepting those at Bremen. Rates vary widely, depending on the quality of the raw water, the size of the sand, and the degree of pre-treatment. Filter media depths vary from 1.0 to 1.5 m. and sand sizes from 0.5 to 1.0 mm. Cleaning of filters used for iron removal is effected in some cases by back flow and flushing to settling basins and to sewers, until the condition of the beds is such that they must be drained and the top sand cleaned. Draining and cleaning of top sand is normal practice in other filters. Cleaning of filter sand is accomplished by removal and washing in machines outside the filters. The mechanically operated "Excelsior" sand cleaner was being used in several plants. It was usually housed in a separate building. At Halle, sand cleaning was done in a series of hoppers with injectors. Removal of sand was by wheelbarrow, cars and belt conveyors.

Rapid sand gravity filters of modern designs are of two types, the BAMAG and the WABAG, the letters representing the names of two large companies which design and install the plants. The headquarters of the fomer company is in Berlin; that of the other is in Breslau in the Russian area of occupation, and was not visited. Both use air and water wash. Filters are rectangular in shape with inlet gullets and wash water overflow weirs and gullets the long way of the filter. The depth of filter sand varies from 1.2 to 1.5 m. (47 to 59 inches). Sand sizes vary from .6 to 1.0 mm. The total depth of BAMAG filters is 2.0 m. (79 inches). The filter sand is placed on 12 inches of gravel with the filtered and wash water manifold pipes setting in the floor of the filter, the nozzle on top protruding into the coarse gravel. Over this is 12 inches of fine gravel overlaid with 55 inches of sand. The pipes in the air wash manifold are placed just above the coarse gravel and midway between the water nozzles.

WABAG filters have the sand placed directly on the bottom slab of the filter box. The slab is made in sections of reinforced concrete with threaded nipples cast through it about 3 3/4 inches on centers. The nozzle or strainer, to which is attached an extension pipe, is screwed into this nipple, the extension pipe protruding into a closed chamber under the filter. When washing the filter, air and water pumped into this chamber rises through the extension pipe to the nozzle and into the filter bed. Slots in the side of the pipe provide outlets for the air and water.

Washing of filters appeared to be effective. No plant reported the formation of mud balls in the filter beds. Both BAMAG and WABAG use nozzles of copper and ceramic material. No surface filter wash equipment was seen in Germany. Sludge from settling basins was usually settled before being discharged to sewers or water ways. Sludge not disposed of in this manner was usually air dried in lagoons.

The modern rapid sand filters are well laid out with wide operating galleries and narrow inspection galleries around groups of filters. Some plants have central galleries with filters on either side, and others have filters on but one side of the gallery. Pipe galleries are well arranged, light and dry. Filter plants are equipped with unit operating tables with hydraulicaly operated control and operating valves. They are equipped with rate controllers, loss of head gauges and flow measuring devices, all with and without recording mechanisms. In the newer plants side windows in the filter rooms are blue glass to prevent algae growths on the filters. Clear wells are under and adjacent to the filters. Sight wells into lighted areas of the clear well are used. In one plant at Osterode the turbidity of the water from each filter is measured at 10 minute intervals by a photo electric cell and a record of the results is registered automatically on a time sheet.

Tub type steel shell rapid sand filters were seen at three plants. Two of these used mechanical rankes and the other one air and water for cleaning and washing.

Pressure filters are used for both pre-and final filtration in conjunction with both rapid and slow sand filters. Single, double and triple deck pressure filters are used. They are usually 1.5 to 2.0 m. in diameter with sand depths of 1 m. in each unit. Sand sizes vary from .6 to 1.0 mm. Wash is by air and water or water and mechanical rakes. Normal rates are from 2.0 to 3.5 gallons per square ft. per minute, depending on conditions.

Chlorination

German water works operators do not give the attention to chlorination that is considered good practice in the U.S. Ground waters are usually of good quality and do not require much chlorine. Usually from 0.1 to 0.2 ppm is applied to the water entering filtered water reservoirs. Residual chlorine is rarely found in any distribution system. Except at Stuttgart where super-chlorination and dechlorination is practiced, the largest amount of chlorine applied to filtered water is 0.6 ppm at the Tegel plant in Berlin. It is customary at this plant to use ammonium sulphate with the chlorine to form chloramines. The ratio of chlorine to ammonia used is 2:1. An effort is made to carry about 0.4 residual chloramine in the reservoir from which water is pumped to the system.

Chlorination equipment is not as well maintained as in the U.S. In general, it is not well housed. Separate rooms for the chlorine and the chlorine control equipment is rare. Chlorine in large capacity containers, equivalent to the ton containers used in the U.S., was observed at only two plants. Periodic weighing of cylinders, to check the operation of chlorine control equipment, is rare. Hourly records of chlorine applied and residual tests are not customary. Duplicate chlorinating units were observed at several plants. Automatically controlled chlorinators were seen at one plant in Berlin and one at Osterode. The use of rotometers to measure the flow of chlorine gas was observed at several plants.

The Stuttgart water works has the most interesting chlorination plant seen in Germany. Here super-chlorination (5 to 9 ppm), is followed by dechlorination through granular activated carbon filters. Dechlorination was being practiced at only one other plant - in the drinking water system at the Buna Werke at Schkopau where the water was dechlorinated by passing it through a granular carbon pressure filter.

QUALITY

The quality of German water supplies as delivered to the consumer is generally good; although in many cities it is very hard. Free carbon dioxide in well waters often ranges from 40 to 60 ppm, and is removed or reduced by treatment with milk of lime as previously described. Iron is common in well waters, ranging from 0.5 to 2.0 ppm; it is removed to less than .05 ppm and often from 0.01 to 0.02 ppm. Manganese in well water may be as high as 1.0 ppm and is almost entirely

removed. The hardness of German water is largely temporary or carbonate hardness, although there are exceptions where sulphate hardness is high. Public water supplies vary in degrees of hardness from 10 to 500 ppm the more common range being from 100 to 200 ppm. German water supply has a pH range of from 7.2 to 8.5.

Micro-organisms of the types experienced in the U.S., are common in surface waters in Germany. Their growth is watched carefully and treatments are adjusted accordingly. The use of algaecides was not reported at any plant. Copper and copper compounds are expensive and have not been readily available during the past decade. Biologic pollution of German water supplies at the source is not heavy except in the case of use of river water. Even without chlorination the quality of water produced at most plants after filtration is bacteriologically of excellent quality. Plants in the larger cities maintain their own chemical and bacteriological laboratories, and the technical control over the treatment is good. Public health officials also collect and analyze samples from the plants and the distribution systems.

STORAGE

Water is stored in underground reservoirs both at treatment plants and at elevated points in the distribution system. The construction of these plants if of brick and concrete and much attention is given to protecting these structures against trespassers and contamination. Entrance doors are kept locked and frequently double doors are used. The structures are usually covered, mounded and turfed or covered with plantings of small trees and shrubs to conceal them. They are well ventilated.

Storage reservoirs in Kassel, Nürnberg and Munich were exceptional in attention given to details of beauty in appearance, accessibility for inspection, lighting, effectiveness of control, and prevention of deterioration of metal facilities, such as gates, valves and piping. The white finish of the concrete, white and light yellow tiling of the entrance and control rooms, and the inspection galleries with ample and effective lighting, all gave to the visitor a very good impression of the care used in assuring the safety of the water to the consumer. At Nürnberg, a visitor must put on special felt shoes over his regular ones before he is permitted to enter the reservoir.

The use of non-corrosive metal in the construction of doors, gates, valves and control equipment, has reduced to a minimum both maintenance and the necessity of workmen entering the reservoir. Much attention was given during the war to camouflaging both underground and surface water storage reservoirs. Inlet and outlet valves and control mechanisms are well housed in rooms separated from the water storage space. Both mechanically and hand operated valve controls were observed. A unique practice at Munich was to collect drainage water from the reservoir in a separate basin and discharge it into wells from which underground aquifiers in the valley were recharged.

Elevated tanks are usually of steel construction, covered and enclosed in attractive brick tower-like buildings. There is often a booster pumping station in the building, and in several instances the quarters of the caretaker and his family were also in the tower building.

DISTRIBUTION

Pipe

Cast iron pipe is the common material used in water distribution systems in Germany, although in recent months considerable steel pipe has been used in making repairs. In general, it may be said that 90 percent of the distribution systems in cities visited were of cast iron. Sizes range from 80 mm up to 700 or 800 mm. Hub and spigot pipe with lead joints was formerly used almost exclusively. In recent years a special screwed nipple and rubber gasket type of joint has come into wide use. It consists of a threaded nipple screwed into the bell of one pipe to squeeze a rubber gasket around the end of the companion pipe which is straight ended. This pipe can be used to make a quick repair and was being used extensively to repair damage to distribution systems as a result of bombing. The design permits considerable longitudinal adjustment at the joint and a degree of curvature which cannot be readily obtained with bell and spigot pipe with rigid jute and lead joints. Under the impact of bombing cast iron pipe fractured into many prices, but the damage usually stopped at a joint.

Steel pipe joints are both welded and coupled using rubber compound ring gaskets. Steel pipe was badly damaged as a result of bombing. The pipe was bent and twisted and often ruptured. At Munich, where damage to transmission and distribution mains was especially heavy, it was reported that often after a steel pipe had been repaired, leaks not previously

noticed were discovered in adjacent sections on either side of the bomb crater. It was the opinion of the city engineers interviewed that a pressure wave passed through the pipe at the time of the bomb impact and caused the pipe to fail at places by collapse or rupture. Cement asbestos pipe had not been used to any great extent in any of the cities visited.

Valves

German valves are similar in general design to those used in the U.S.

Hydrants

Two general types of hydrants are used in Germany: (1) the underground, and (2) the above ground. The former is much more widely used, but the tendency is toward the latter, especially in the industrial and high property value sections of the large cities and also at large industrial plants built in recent years. The fire department officials definitely favor the "above ground" hydrant.

Objections to the use of the underground hydrant are based on these facts: (1) the cover is flush with the street or sidewalk and an extension pipe with a bayonet type of fitting must be slipped over the outlet of the hydrant before it may be used, and (2) difficulty is experienced with freezing unless the riser pipes are wrapped by insulation.

Service Pipes

Lead was formerly used for service pipes but now galvanized iron pipe is preferred. Very little copper tubing is used as this metal is not only quite expensive but has been difficult to obtain since the war.

Meters

Water services are practically all metered. The most common meter used is the disc type. "In-line" meters are used in the larger service. Hard rubber and plastic are used for discs and impellors. Gears made of an impregnated fibre were used in some of the meters seen.

WAR DAMAGE

The water systems of Germany have been damaged heavily as a result of the war actions - especially bombing. All units have been affected, but the greatest toll was in destruction of principal transmission and distribution mains. Some idea of the destruction of these facilities may be obtained from the number of breaks reported in certain large cities, as follows:

City	Kilometers of Pipe in Distribution System	Number of Breaks in Distribution System
Essen	1,000	2,000
Munich	1,700	1,860
Bremen	1,200	1,200
Nürnberg	677	1,200
Halle	362	200
Hagen	60	200

The extent of damage in cities is of interest. In Essen, as much as 2 percent of the total length of pipe in the distribution system was destroyed. At Nürnberg, four of the five transmission mains between the principal source of supply and the city were damaged. Destruction of transmission mains by bombing and as a result of demolition by the retreating Germans caused many cities to be without water in several sections of their system for many weeks. Typical examples were Hagen, Bremen and Nürnberg.

Damage to filtration plants was not great. Bremen was an exception, however, because in spite of extensive camouflage, 11 of 22 show sand filters, one of two settling basins, and a clear well were put out of service at the time this plant was visited.

Damage to pumping stations, one of the most vulnerable units of a water works system, was not extensive, except in the case of industrial plants where intensive bombing was carried out. The Leuna chemical plant was a good example.

The many emergency measures taken by the Germans to maintain water supply for the bare necessities of community life were extremely interesting, but are not properly a part of this report.

DETAILED TARGET REPORTS

TARGET NO.A-1

Name:	City of Leipzig Water Works
Location:	Leipzig and vicinity
Dates Visited:	June 1, 2, 4, 1945
Persons Interviewed:	Paul Sierpert, obermaster, Thekla W. Wks., Paul Matthes, obermaster, Probstheide W. Wks., W. D. Pfeiffer, director, Leipzig W. Wks.
Interviewed By:	A. E. Gorman

INFORMATION OBTAINED

General

The population of Leipzig in 1940 was 750,000. In June 1945, the estimated population was 350,000, with an additional 100,000 in the suburbs. The central section of the city and even the suburban areas were seriously damaged by aerial bombing and public utility facilities suffered heavily. Damage to principal water mains and sewers was especially heavy. Records of the water system were destroyed by fire and were not available.

Sources of Supply

All water in the Leipzig area is from wells. The entire region is underlain with sand and gravel which is saturated with water. Ground water recession is not common.

The principal sources of supply for the city water system are:

Plant	Year put in Operation	No.of wells	Rated capacity m^3 per day
Naunhof I	1886	212	30,000
Naunhof II	1895	221	30,000
Canitz	1912	400	60,000
Thallwitz	1929	58	40,000

The Canitz and Thallitz plants were in the Russian area of occupation and were not visited.

In the suburban areas around the city there are seven water systems each supplied by wells. These systems are interconnected with the Leipzig system, but normally supply only the local area in the vicinity of the plant. These seven systems serve about 100,000 people and supply an average of 15,000 m^3 per day.

Wells used for public supplies are usually 12 to 15 meters deep. Before the war, screens of copper alloys were used with discharge pipes of cast iron but because of the shortage of copper, screens installed in the more recent wells were made of fluted glazed ceramic material. Outside the screen the well is packed with graded gravel, medium and small. Above the screens the well is packed with gravel. The wells are operated under a partial vacuum. The valve pits at ground level are of reinforced concrete and/or brick construction. Covers are of cast iron, well sealed and locked. The collecting pipes between wells are cast iron. The water is delivered to a central receiving well from which the pumps take suction, discharging either to the treatment plants or to the city.

Many industries in Leipzig have private wells, and at various points throughout the city there are wells from which water can be obtained using hand pumps. There were about 200 of these wells before the war.

Treatment

Naunhof: There are two plants at Naunhof, No.1 and II. Wells, about 10 m. deep, are the source of supply. The No.1 plant was the first ground water supply developed in Germany. The water is treated with lime to remove CO_2 (64 ppm), and thus prevent corrosion of the three large cast iron mains, diameters 1.0, 0.8 and 0.8 m., through which the water is pumped from this source to the Probstheide treatment plant 12 Km distant. Treatment is accomplished by pumping a saturated solution of hydrated lime into four pressure tanks in which it is mixed with water.

Canitz: (not visited). The wells at this plant are 14-18 m. deep. The water contains CO_2 (60 ppm), and also 0.5-0.6 ppm manganese, but no objectionable amounts of iron. It is treated with lime in the same manner as at Naunhof to remove the CO_2, and the manganese is reduced to 0.1 ppm in 12 Mangan triple decked filters. Chlorine (0.1 ppm) is used periodically. The treated water from this plant is pumped through concrete and cast iron conduits, diameter 1.1 m., to the Machern reservoir (covered) 13.0 Km distant, from which it flows by gravity to the storage reservoirs at Probstheide for distribution without further treatment.

Probstheide: The lime treated water from the Naunhof plants is filtered at Probstheide without aeration to remove iron. There are two covered slow sand filters each divided into 12 sections. The total sand area is approximately 2,310 m^2. The average rate of filtration is 48,000 m^3 per day or a gross rate of 20.7 m^3 per day per m^2 of filter area. This is equivalent to about 23.3 million gallons per acre per day. The filter sand is 1.5 m deep, and is placed over 1.0 m of graded gravel. The filters are backwashed once a week to a settling tank which drains to the sewers. Sand is removed from each filter unit and cleaned about once in eight years.

Thallwitz: (not visited). This plant, built in 1929, has a capacity of 40,000 m^3 per day. The well water contains 40-50 ppm of CO_2, 0.8-1.0 ppm of manganese and a negligible amount of soluble iron. The water is aerated to reduce CO_2 to 12.0 ppm, using pressure nozzles. There are eight open Mangan filters, four on each side of a gallery, used to reduce the manganese to 0.1 ppm. Each filter has an area of 48 m^3 (4 x 12), and filter media depth of 1.5 m. The average diameter of the sand is 1.0 mm. Chlorine is applied to the filtered water when necessary.

In the suburban plants the well water is treated as follows:

Plant	Treatment
Grosszschölchern	Chlorination
Leutsch	"
Wohren (1)	Iron and manganese removal; chlorination
Wohren (2)	Iron and manganese removal; chlorination
Mockau	Iron removal; chlorination
Schonefeld	Iron removal
Paunsdorf	Iron removal

Pumping

Three old horizontal fly wheel reciprocating steam pumps are used in each of the two Naunhof plants. Their capacity is 14,400 m^3 per day. At Canitz there are two low lift steam pumps (34,500 and 55,000 m^3 per day capacity), and two high pressure electric driven centrifugal pumps each of 30,000 m^3 per day capacity. The Thallwitz plant has two motor driven centrifugal pumps each with a capacity of 20,000 m^3 per day. The Probstheide station has motor and diesel

engine driven booster pumps for service to high pressure areas. Other booster pumping stations are operated at strategic points in the system. The diesels are standby units and were used when there were power interruptions during the war.

Distribution

The system contains 900 kilometers of cast iron pipes. Sizes vary from 1200 mm to 80 mm in diameter. The most common sizes of pipes are 100, 150 and 200 mm in diameter, representing about 60% of the total length of the system. There are approximately 1200 hydrants in the system, 10% of which are underground. Above ground hydrants are used in the high property areas and in the vicinity of new war plants. They are preferred by the fire department because of capacity and accessibility in winter. During cold winters some difficulty is experienced with freezing of the underground hydrants. This is minimized by winding the riser pipes with rope dipped in a bituminous compound. (See Fig. A-1-a).

Service pipes are of lead and galvanized iron. Bakelite, plastic and porcelain have been tried but were not satisfactory. All services are metered.

Storage

The principal storage point in the city is at the Probstheide plant. There the locally filtered water from the Naunhof stations and the filtered water from the Canitz plant is mixed and storied in 10 reservoirs with a total capacity of 82,000 m^3. Flow to the city is by gravity. There is a steel elevated tank at the Probstheide plant (see Fig.A-1-b), which houses both the booster pumping station and the elevated tank serving the higher section of the city. Pressures in the city range from 40 to 60 psi.

Storage of filtered water at the Canitz and Thallwitz treat-plants is in underground covered reservoirs. The capacities are 1500 and 2000 m^3, respectively.

Quality

The water in the city is normally of good sanitary quality, chemically and bacteriologically. However, due to the high CO_2 content of the water and the large number of lead service pipes in the system, there was in 1930, an outbreak of 50 severe and 200 minor cases of lead poisoning among citizens. The use of lime to remove CO_2 was inaugurated after this outbreak, and now only galvanized iron service pipes are used.

There are laboratories at the Probstheide, Canitz and Thallwitz plants. Bacterial tests are made daily. The health department normally collects samples from 20 points in the distribution system every other day. Considering the number of breaks in the mains the reported results of bacterial analyses of samples from the distributing systems were surprisingly good, but because of limited facilities enough samples were not being taken to be representative of the condition of the water supplied consumers in all sections of the city.

War Damage

The transmission and distribution systems were seriously damaged as a result of war actions, especially by bombing. There were periods when large areas of the city were without water except that supplied at special water points and under emergency conditions. Fire service was inadequate to cope with war conditions even though there were numerous static water storage points in the city.

The most serious damage resulted from breaks in transmission lines to the city. On April 6, 1945, four bombs dropped in an open field near the village of Grosspossna about 6 kilometers from Naunhof, and broke two of the three double ring brick gravity conduits which deliver water to the Probstheide station. (See Fig. A-1-c). The bombs created craters about 300 yards apart. The cover over the conduits was sand and clay. (See Fig. A-1-d). The following is a summary of conditions at these points of damage:

Crater No.	Conduits Broken	Diameter of Crater in Feet	Cover over Conduits in Feet
1	1	30	7
2	1	30	7
3	2	30	8
4	2	90	12

Fortunately, at the time of this bombing the Probstheide reservoirs were full and by conserving water the supply to the city was not exhausted. The conduits (gravity flow) were repaird temporarily by constructing wooden flumes. They were under repair at the time of inspection on June 2, 1945.

It was reported that one of the two 1.1 cast iron and reinforced concrete conduits from the Canitz plant was also damaged as a result of this attack. The site of the damage was not visited as it was in territory occupied by the Russians.

The following table, obtained from reports on file at the Military Government, shows the amount of water which was supplied progressively to the Leipzig system first from the auxiliary and later from the major sources of supply, following occupating by American forces:

Supply of Water to Leipzig from Various Sources Following Bombing of April 6,1945

Source	Thousand cubic meters			
	April 27	April 30	May 30	June 8
Naunhof I	0	0	29.2	29.8
Naunhof II	0	0	28.0	16.7
Canitz	0	30	42.0	21.0
Thallwitz	0	0	0	19.1
Probstheide(Filters)	0	0	0	0
Suburbs (Wells)	17	17	13.0	13.0
Industries (Wells)	12	31	6.0	3.0
Emergency Wells	20	?	?	?
Total	49	78	118.2	102.6
Percent of Normal	37.0	59.0	90.0	77.5

As a war emergency measure, the city constructed 42 wells of the type shown in Fig. A-1-e, from which in emergencies water could be obtained to supplement the normal public water service. Pumping from these wells could be by hand at neighborhood water points (see Fig. A-1-f), or by gasoline or diesel engine driven pumps (see Fig. A-1-g). These portable pumps were used to pump (1) directly into the city mains through hydrants; (2) to temporary above-ground emergency systems - hose or quick joint steel pipes; (3) to water tanks, or (4) to fire fighting equipment. Water buildings and established water points for public use were also supplied, using hose attached to fire hydrants. (See Fig. A-1-h).

Points of Special Interest

Points of particular interest in the Leipzig water works system were: (1) the treatment of the water by a solution (milk of lime) of calcium hydrate; (2) the removal of manganese in pressure or gravity filters; (3) the use of emergency wells during the war to supplement the normal sources;

(4) the emergency pumping facilities for use when the system was damaged; (5) the protection of underground hydrants from freezing; (6) the breaks by bombs of the principal sewers (see Fig. A-1-i, j, and k), and (7) the damage and method of temporary repair to large transmission mains also broken by bombs.

TARGET NO. A-2

Name: Halle Water Works

Location: Halle

Date Visited: June 6, 7, 1945

Persons Interviewed: Schmidt, director, Heuerman, chief engineer

Interviewed By: A. E. Gorman

INFORMATION OBTAINED

General

In 1940 Halle had a population of 220,000. It is an industrial city that was seriously damaged by several heavy bombing attacks. The city required an average daily supply of 36,100 m^3 or 43 gallons per capita.

Sources of Supply

The supply is from 395 wells, 10 m deep and spaced 27 m apart, located in low land lying between the Elster and Salle Rivers in the village of Beeson, about 5 miles south of the city. The well screens are 150 mm diameter, 200 mm long and are made of copper covered with tin. The slots are vertical, 2 inches long, 1/8 inch wide and spaced $1\frac{1}{4}$ inches apart. Water from the wells is brought into a central collecting well across the Elster from the plant, by four cast iron mains 750 mm in diameter. The wells have a total capacity of 55,000 m^3 per day. The field was first developed 40 years ago, but the number of wells has been increased from time to time.

Treatment

The well water contains iron (.4-.25 ppm) and manganese (.5-.36 ppm), which is removed by aeration and filtration. It is pumped to a central well in the aerator house where it enters a steel plate manifold flume from which it is delivered to a series of lateral flumes discharging onto six aerator units. The water falls through holes spaced about 4 m apart, in each side of these lateral flumes onto three wooden planks arranged in steps or cascades over a fall of about 18 inches, is collected in shallow pans about 4 x 6 feet in

area, and discharged from there onto stacks of brick. The bricks are stacked, one layer flat and the next standing sideways, with openings about 2 inches between each brick. The fall through these stacked bricks is 4 meters. They are removed, dried, scraped of sludge (about 2 inches thick), and replaced about once in 4 years. The collecting basins under the brick aerators collect sludge to a depth of about 450 mm in a year. They are then cleaned by flushing and drainage to the river. The proportion of oxidized iron and manganese sludge removed was estimated to be 25 percent on the bricks and 50 percent in the basin. Water discharged from the settling basins to the pressure filters is treated with 0.6 ppm chlorine. This quantity is increased as necessary when the well fields are flooded.

There are 5 reinforced concrete rapid sand gravity filters each 5 m. in diameter. The sand depth is 1.0 m. and the size 1.0 mm. Each filter is rated to operate at an average rate equivalent to about 2.0 gallons per sq. ft/min. The rate, however, is frequently exceeded. The filters have peripheral inlet and wash water troughs, and are equipped with rate of flow and loss of headgauges. During washing the sand is agitated by revolving rakes moving at a speed of one revolution in 10 minutes. They are cleaned about once in 10 days. Valve operation is manual. Algae growth on the filter is prevented by the use of green glass in the windows of the filter house.

After rapid sand filtration the water is passed through slow sand filters. There are six of these filters each 6 x 25 m. in area. It was reported that each has a rated capacity of 3000 m^3 per day, or the equivalent of 21.5 million U.S. gallons per acre per day. The sand is 1.0 m. deep; its size is about 0.5 mm. About 2 cm of "schmutzdecke" are cleaned from each filter once in three weeks. The filter sand is removed and cleaned annually. Cleaning is by flow through a series of four hoppers with water injectors at the base. This machine will clean 20 m^3 in a 10 hour day with one operator and four car and shovel men. Water pressure for the injectors is about 100 pounds per square inch.

Filtered water is stored at the plant in a covered reservoir of 14,000 m^3 capacity.

Pumping

The low lift pumps from the collecting well to the aerators consist of one new motor driven deep well pump of 38,400 m^3 per day capacity and three vertical crank and fly wheel steam engine driven reciprocating pumps each of 12,000 m^3

per day capacity. Three old pumps, two of which were installed in 1897, were operated in May when there was a shutdown of electric power.

The high pressure pumps are two motor driven centrifugal units of 16,700 and 21,600 m^3 per day capacity respectively. There are also two 40 year old crank and fly wheel horizontal steam engine driven pumps each of 10,800 m^3, used only for standby service. The high pressure pumps are operated at a pressure of 80 atmospheres (118 psi) at the pumps.

There are five principal transmission mains from the plant to the city. Four are cast iron 700, 600, 450 and 390 mm in diameter, and a fifth 650 mm in diameter is of reinforced concrete.

Distribution

Water is pumped from the plant directly to the city system. The system consists of 362 kilometers of cast iron pipe ranging from 500 to 80 mm. Sixty percent of the pipe length is in the 80-200 mm range. There are three steel elevated storage tanks which float on the system. They are enclosed in attractive brick towers. Their capacities are 1200, 2000 and 3000 m^3 respectively. The pressure in the distribution system is about 50 psi. There are approximately 4000 fire hydrants.

Quality

The following table summarizes the chemical quality of the well water before and after treatment:

	Before Treatment	After Treatment
	ppm	ppm
Ph	7.10	7.50
Manganese	.5-.36	0
Iron	.25-.40	.06
Hardness	-	247.0

The bacterial quality was reported to be excellent in normal times. Records of recent bacteriological analyses were not available at the time of inspection.

War Damage

There were 200 breaks in the distribution system mostly the result of bombing. The breaks varied in size from 10-30 meters in length. It was estimated that 2 kilometers were destroyed, which is .55 percent of the total length of pipe in the system.

Three of the five transmission mains - the 700, 600 and 450 mm. cast iron lines - were broken. Fortunately, by conservation it was possible to maintain service through the other two. This limited the use of water to about 12.5 liters (3.3 gals.) per capita per day.

For emergency water supply during the war, the city built 60 brick and concrete open storage tanks at various locations in the city from which water was pumped for fire fighting and for emergency service to overground pipe and hose laid to numerous water points. The total capacity of these tanks was 65,000 m^3 or equivalent to 45 hours normal requirements. The water treatment plant was not destroyed.

Items of Special Interest

This system has nothing of special importance to American and British water works officials. The completeness of treatment, the aeration plant and the sand washers are of general interest.

TARGET NO. A-3

Name:	Buna Werke Water Works
Location;	Schkopau
Date Visited:	June 8, 1945
Persons Interviewed:	Bechdolt, Mains, Gaydoul
Interviewed By:	A. E. Gorman

INFORMATION OBTAINED

General

This plant, located about 7 miles south of Halle, manufactures synthetic rubber and rubber products. When operating at capacity about 12,000 persons were employed, half of whom were slave laborers living in a nearby camp. The plant was put into operation in 1936, and enlarged progressively for war production. Several units were damaged by bombs but generally the destruction of facilities was not great. This plant was selected as a target because of its modern water supply, treatment process, and related equipment.

Sources of Supply

There are three principal and separate water systems at this plant known as: (1) drinking, (2) cooling and (3) plant. Data regarding each are summarized in the following table:

Water Systems at Buna Werke - Schkopau

Water system	Year put in operation	Source	Treatment	Output in: m^3 average	Day maximum
Drinking	1943	Wells	CO_2, Fe and Mon. removal$_2$ Cl_2	1,680	3,360
Cooling	1938	Wells	None	4,800	7,200
Plant	1936	Salle River	Filtr.-Cl_2	240,000	336,000

Drinking Water: When the plant was first operated in 1936, drinking water for employees at the plant and in their homes was obtained from the system of the town of

Tratler. This water was not of good quality so wells 11-13 m. deep were constructed near the plant and the Salle River using screens of ceramics 200 mm. in diameter. The wells are operated under a vacuum system discharging through cast iron collecting pipes to a central receiving well from which the water is pumped for treatment. The capacity of each well varies from 8 to 12 m^3 per hour, depending on the elevation of the adjacent river.

The drinking water receives preliminary treatment for the removal of carbon dioxide, iron, and manganese after which it is stored in two ground reservoirs each of 300 m^3 capacity. From these reservoirs it is pumped to the distribution systems which supply the plant, the nearby housing communities for the plant operators and executives, and to the labor camp. In 1944, the average use of this domestic water was 164 liters (43.5 gallons) per person per day.

Cooling Water: Fourteen wells similar to the drinking water wells provide water for the cooling water system. This water is not treated. The temperature of the well water varies from 12° to 6.0°C, whereas the temperature of the Salle River water is from 28° to 2.0°C.

Plant Water: This water comes from the river where water enters a forbay protected against current action by a sheet piling wall which prevents deposits of sand from the river bed. The water is screened through two sets of duplicate revolving screens which are automatically cleaned. (Figs. A-3-a-b-). It is electrically heated to prevent ice troubles in winter. The inlet screen basin construction is such that if one pair of screens is out of order, water to both inlets can pass through the other set of screens. The screened water flows by gravity through two steel pipes (2.2 m. diameter) to the low lift pumps in the main pumping station from which it is delivered to the settling basin operated in conjunction with the filtration plant.

Treatment

Drinking Water: The drinking water is treated for CO_2 removal in a cone shaped reactor (see Fig. A-3-c), which is charged with very fine quartz and marble (see Figs. A-3-d a and e). The water and milk of lime is pumped into the bottom of this tank and caused to pass up through the quartz and marble in a spiral flow, discharging at the top. When the deposition of calcium carbonate on these media increases the grains to 3 mm. diameter, they are removed and more fine

material is added (see Figs. A-3-f and g). The water is then chlorinated and filtered through two pressure filters for iron and manganese removal, and passed through two activated carbon filters for polishing and removal of possible excess chlorine (see Fig. A-3-c).

Plant Water

The Salle River water, while normally reasonably clear, is subject to turbidity, micro-organisms and pollution. In the summer and fall months wastes from sugar beet plants, paper mills and phenols from byproduct coke plants are especially objectionable. There is also some sewage pollution in the river. It must, therefore, be treated for general process uses in the plant.

The treatment consists of preliminary settling without coagulation, rapid sand filtration and chlorination. The screened river water is first pumped to six reinforced concrete settling basins, each with a capacity of 2400 m^3. Experiments indicate that without the use of coagulents, 60 percent of the suspended matter is removed in these basins in one hour. A cable drawn mechanical scraper moves the settled sludge into a sump across each tank near one end. (Fig. A-3-h). Sludge is withdrawn through special suction pipes installed in the sump and to which connection is made to the suction of a centrifugal pump. The pump is installed in a special housing mounted on a chassis which travels on tracks across the basins and can, therefore, serve each in turn. Sludge is removed about once each day.

Governmental restrictions on the discharge of wastes containing suspended matter into the Salle River, make it necessary to settle this sludge as well as the wash water from the filters. The settled sludge and wash water is delivered to two concrete receiving basins located near the river. Their use permits continuous operation of the sludge settling basin. Each receiving basin has 200 m^3 storage capacity. The sludge is concentrated by the Neustädter-Becken system operating in the following manner (see Fig. A-3-i): The stored sludge is pumped to two horizontal settling tanks each containing two parallel compartments. The side walls are vertical and the concentrating chamber at the bottom is V-shape. The settling period is one hour, and operation of the tanks is intermittant. When sludge is to be withdrawn long triangular blocks of concrete, suspended by cables to eyes in the apex of the block, are lowered to seal off the sludge compartment from the settling tank proper, and a sludge scraping mechanism rolling on tracks, is

then drawn by a cable through the closed V-shaped horizontal hopper. At the same time, the sludge outlet valve at the opposite end is opened permitting the flow of sludge into a receiving compartment. Under the hydro-static head of water in the tank aided by the scraper, the concentrated sludge is forced out of the settling hopper. It is then pumped to four air drying basins. The Neustädter-Becken tank handles 15,000 m^3 of settling basin sludge and filter wash water per day. The supernatant liquor from the tank is discharged to the river. This sludge concentrating tank can be used with or without coagulents. The sludge scraper consists of a flat plate of steel set at an angle of about 45 degrees in a frame designed to pass through the temporarily closed sludge settling compartment with minimum clearances. After it has pushed the sludge out, the scraper is drawn back by reversing the direction of the movement of the cable. Until it is ready for reuse it rests on top of the basin at one end.

The rapid sand filtration plant is of the most modern WOBAG type. There are 16 double filters, eight on each side of a gallery. Construction is reinforced concrete, the walls of the inlet gulletsforming the long side of each filter box. The wash water troughs - one to a filter - are of light concrete construction and parallel the inlet gullets midway across the filter. The following table summarizes the important physical design and operating features of the filter units:

	Units of Measurement	
Item	German	American
Area - double filter	150 m^2	1,614 sq.ft.
Length	25 m	82.0 ft.
Width - double filter	6 m	19.6 "
Volume of filter sand	225 m^3	295 cu.yds.
No. nozzles per unit of area	90	104
" " " filter	13,500	13,500
Normal filter capacity ea.hr.	625 m^3	165,000 gals.
Max. " " " "	800 m^3	211,000 "
Normal " " total hr.	10,000 m^3	2,642,000 "
Max. " " " "	12,800 m^3	3,370,000 "
Normal ratefiltration per min.	.7 m^3/m^2	1.9 gals/sq.ft.
Max. " " " "	.89 m^3/m^2	2.2 gals/sq.ft.
Normal filter runs - hours	12-20	12-20
Time of wash - min.	10-15	10-15
Air used per wash	3,000 m^3	106,000 cu.ft.
Wash water per wash	450 m^3	118,000 gals.
Percent wash water	3.1-4.5	3.1-4.5

An interesting feature of this plant is the fact that the filter sand, 1.5 meters deep, is placed directly on a slab filter bottom into which the discharge nozzles are screwed (see Fig. A-3-j). The individual cross reinforced slabs which form the filter bottom are 1 m. long, 0.5 m. wide and 125 mm thick. (Approximately 39 x 18½ x 5 inches). They set on cross frames to which they are anchored by bolts and held to one another by a steel plate. The nozzles are about 2 inches in diameter. The caps of the copper ones are screwed to an extension pipe about 15 inches long and 3/8 inch in diameter. The caps of the porcelain are cast integrally with the extension pipe. The nozzle and pipe are screwed into an internally threaded sleeve cast into the slab. The extension pipe protrudes into the space or compartment under the filter bottom into which the filtered water is discharged and through which water and air are pumped when the filter is washed. Slots in the side of these extension pipes permits air which is compressed in the top of the compartment to enter the pipe, mix with the water and pass upward through the nozzle and into the filter. Air and water may be used separately or in combination, and a pipe is provided for exhausting the air to the atmosphere when its use is not necessary.

Filter washing by this method was uniform and effective. During inflow of water to the filters a doughnut shaped float of sheet copper (and in some cases bakelite) automatically closes the valve to the wash water outlet. The filtered water reservoir is under the filters and is an integral part of the filter box and foundation. Chlorine may be applied to the water (0.1 ppm) in the suction line to the high pressure pumps. It is purchased in large containers holding approximately 1.0 Kg.

The filter operating gallery between the two sets of 8 filters is about 25 feet wide. (See Fig. A-3-k). The tables are constructed of marble slab grouped in units of four. Valves are automatically controlled and all piping to and from them and to the operating tables is of copper. There is also an access gallery around each set of 8 filters. Each filter is equipped with a rate controller (Fig. A-3-m). Recorders for filtering rates are provided. The general appearance of the filter room compares favorably with modern plants in the U.S. and U.K.

The pipe gallery is spacious, dry and well lighted (see Fig. A-3-l). Piping is of cast iron and all large valves are hydraulically operated.

Pumping

The pumping station is of modern design and well equipped. All pumping units are electrically operated (see Figs.A-3-n and o). Power is from two different sources and if one fails the other is automatically cut in. One-half of the pumps are on each source of power at all times. Pumps and auxiliaries can be controlled from a central station located in the gallery (see Fig. A-3-p). Electrical switching and control equipment is well housed and modern in every respect.

The check valves and automatic cone valves on the discharge of the motor driven pumps are interesting (see Fig. A-3-q). The velocity in the by-pass around the check valve can be regulated to adjust the time of closure. If the power goes off, an oil piston in the cone valve operates the internal moving part of the valve, changing the diameter of the opening and closing it without excessive vibration. This valve also measures flow according to the Venturi principal.

The following summary lists the equipment in the water works pumping station:

Unit		Rated Capacity m^3/hr	Kw
Low head pumps	3	5,000	250
" " "	2	2,500	120
High head pumps	1	5,000	1,380
	2	5,000	1,250
	2	2,500	660
Wash water pumps	2	1,800	62
Blowers	2	13,500	245
Vacuum pump	2	345	11
Drainage pump	1	50	2.2
" "	1	10	.55
Sludge pump	1	40	1.1

Heavy reinforced concrete structures were built to give protection to pumps, motors and transformers in case of bombing. Those for the pumps and motors were semi-eliptical in shape, made in 1 meter sections and about 250 mm thick; those around the transformers were cylindrical with a top slab 400 mm thick.

Distribution

This plant has separate distribution systems for the drinking water, the cooling water and the filtered river water used for general plant processing. Cast iron is used for the smaller mains and steel for those in excess of 800 mm. Interesting photographs of the constructions of each pipe system are shown in Fig. A-3-r. Special attention is directed to the method of making joints in the pipe as shown in Fig. A-3-s.

Joints in cast iron pipe are made with lead and hemp or by a special screw type joint which has become standard in German pipe practice. (See Figs. A-3-s and A-3-t) It is very practical, has given excellent service in making emergency repairs during the war, and in addition it saves both lead and hemp, which are scarce. This joint is described in paragraph 3, page 11.

Steel pipe joints were welded in the field. An interesting joint was one made by bending overlapping steel of a flared end of one pipe over a special shaped end of the companion pipe and welding the edges of the overlap to the outside of the second pipe. (See Fig. A-3-s) This joint was used considerably at this plant where many bends had to be made. Steel pipe was supported by concrete saddles and all pipes as installed were embedded in sand. Special anchorage was provided to take care of thrust at bends.

The following summary gives the length of pipe of all kinds used in the various systems of this modern plant:

Meters of Pipe in System

Pipe Diameter mm	Drinking Water System	Cooling Water System	Filtered River System For Plant	Filtered River System For Condensers
1200	-	-	6352	69
1000	-	-	-	324
800	-	-	3327	2266
600	-	-	-	8
500	-	-	6045	1971
400	-	1364	1322	1055
350	-	-	95	-
300	-	-	1640	579
250	800	3945	820	25
200	1420	1548	2016	56
150	3310	200	3581	69
125	1090	-	480	-
100	9150	410	5184	-
80	2645	125	4430	-
50	1300	290	983	-
Under 50	6570	70	3098	-
Total	26,285	7,952	39,273	7,422

Grand Total......... 80,932

The system is liberally valved for effective operation and repair. The total number of valves in these systems is:

System	Number of Valves
Drinking Water	631
Cooling Water	170
Filtered River Water Plant	599
" " " Condenser	293
Total	1,693

Both above and under ground hydrants are used in the system. The above ground type are used around the plant where fire protection is a most important factor. The underground hydrants are used on the smaller pipes and in the residential area. Illustrations of these standard German hydrants are shown in Figs. A-21-a and b. Automatic air valves are used at high points in the system. All hydrant, valves, and important oper-

ating accessories are identified as to size, type and location by enamelled signs placed on the walls of buildings in the street paralleling the pipe and also at street intersections. The colors in the sign indicate the type of water system. Arrows indicate the direction and distance to the valve or hydrant from the sign. Letters "S" and "A" indicate main and branch valves respectively. The letter "H" indicates a hydrant. A number opposite the letter indicates the size in mm of the pipe, the valve or hydrant is connected into. Manhole and valve covers are similarly identified by special marking and letters cast in them.

Special portable motor driven valve opening machines are used because of the number of large valves and the necessity of making quick shut-offs for repairs in emergencies. The unit is mounted on a trailer which can be attached to a truck for quick service. (See Fig. A-3-u) The battery powered motor has four speeds.

Special precautions were taken to meet emergencies affecting the water systems at this plant because operation without water supply would be impossible. The condenser water system with its cooling towers and recirculating pumps was divided into two separate units so one could be operated if the other were damaged. Arrangements were made to pump raw river water to the condenser system if necessary. In case of fire, water could be pumped from several sources; (1) a storage reservoir on the grounds, (2) a nearby swimming pool, and (3) a canal. Provision was even made to close the valves outside the plant on the cooling water and rain water drainage systems, so that in case of emergency this water could be used by lowering the suction of emergency pumps into them through manholes.

Quality

The quality of the water from the various sources before and after treatment is given in the following table:

Quality of Water Supply at Buna-Werke, Schkopau*

	Drinking Water		Cooling Water		River Water	
	Av.11-1944 Before	Av.11-1944 After	Av.3-1944 Before	Av.3-1944 After	Av.3-1944 Before	Av.3-1944 After
Ph	7.46	9.18	7.41	-	8.19	7.51
Carbonate Hardness	11.4	2.70	12.4	-	8.10	7.50
Total Hardness	26.3	18.0	25.6	-	22.6	21.8
Turbidity	None	None	None	-	No test	No test
Total Solids	800.0	800.0	926.0	-	657	760
Iron	1.81	.13	1.91	.5	7.2	.45
Manganese	.75	.04	.61	-	0	0
CO_2	38.4	0	30.8	-	41.0	12.9

*Data from Dr. Manz, chief chemist.

The bacterial quality of the water is checked by daily analysis at the plant laboratories.

War Damage

The plant was first bombed early in December 1944 and several times thereafter. One of the two principal discharge lines to the settling basin for treating river water was damaged. Late in January a second was broken. Three bombs struck the settling basins, breaking the outside wall of one and cracking two inside walls so that three of four basins in the first unit could not be used. Another bomb damaged the side wall of the filter building, and a third larger one broke through one double filter and sheared a hole through the box into the filtered water reservoir. It will be necessary to rebuild this unit completely, and also the roof over this section of the filter building.

Items of Interest

From the point of view of modern equipment used and multiplicity of operating problems encountered, this was the most interesting plant water works system seen in Germany. The illustrations in the A-3 series might well be carefully studied by everyone interested in water works engineering.

TARGET A-4

Name: Kassel Water Works

Location: Kassel

Date Visited: June 11, 1945.

Persons Interviewed: Dr. Ing Hugelmann, Chief Engineer

Interviewed by: A. E. Gorman

INFORMATION OBTAINED

General

Kassel is an industrial city with a 1940 population of 230,000. About 40 percent of the water was used by industry. The central portion of the city was very heavily bombed and destruction was intensive. The normal amount of water supplied was 50,000 m^3 per day or about 57 U. S. gallons per capita. At the time of inspection it was estimated that the civilian population in the city was 80,000. The amount of water being supplied was 25,000 m^3 per day. Time available for inspection at Kassel did not permit an inspection of all plant in the system nor the collection of complete operating data.

Sources of Supply

Seventy-eight percent of the water supplied the city is from wells, and the remainder is from springs. The following table summarizes the capacity of the various sources:

KASSEL WATER WORKS SYSTEM

Sources	Capacity m^3 per day
I. Springs.	
Bergfreiheit	300
Hessenschanze	480
Druseltal	1,300
Kuhberg	320
Bergstrasse	800
Dönche	2,200
Brasselsberg	250
Heinrich Schütz-Allee	200
Schenkelsberg	150
Nieste	5,000
Total springs	11,000
II. Wells.	
Neue Mühle	20,000
Tränkeweg	7,500
Forst	7,500
Eichwald	10,000
Holländische Strasse	5,000
Total wells	50,000
Grand Total	61,000

The springs outcrop from the mountain on the east and west side of the city. Water flows into receiving basins and is supplied by gravity or pumping to the distribution system and storage reservoirs. One of the spring sources (Drusethal) is from a mine, and as the water contains from 0.8 to 1.4 ppm soluble iron it is filtered.

The wells supplies are generally free of objectionable amounts of iron. The exceptions are Tränkeweg and Holländische Strasse where the range of iron is 0.4 to 1.3 and 0.2 to 0.8 ppm respectively. Wells are both deep and shallow. Typical of the former are the Hollander Strasse (180 m) and Eichwald (81.0 m). (See Fig. A-4-a) The bore hole of the former is 650 mm in diameter. The wells at Neue Muhle are typical of the shallow wells. Because of the shortage of steel, tile pipe was used for casing. There are 45 wells, 16 m deep, bore hole 600 mm and screens 300 mm diameter, and spaced 10 m apart. The shortage of copper products has caused the use of other materials for screens. Ceramic material has been used in some; steel covered with hard rubber was used in several wells constructed during the period 1935-1939; and in 1941 the slotted screens on two wells were constructed of oak wood staves. To date they have given satisfactory service. The wells discharge through 450 mm cast iron collecting pipes into a central well.

Treatment

An interesting iron and hydrogen sulphide removal plant constructed during the war period was in operation at the Trankweg well plant. The two filter tanks were constructed of reinforced concrete because plate steel was not available. This construction saved 10 percent in cost and 80 percent in steel. They are 4 m in diameter and 4 m high. Air is pumped into the discharge line between the well and the filters. The aerated water is filtered downward through 2 m of crushed marble about 1.0 mm in size. The marble sand rests on a cement-asbestos slab into which porcelain nozzles are screwed. The nozzles are spaced 100 mm on centers. There is a storage basin under the filter into which air and water are pumped when the filter is back washed. Removal of iron is from 1.3 to negligible amounts. All hydrogen sulphide is removed and released through an air vent.

Transmission

Pipes of steel, cast iron and re-inforced concrete are used in transmission of water from sources to the system. Steel and reinforced concrete are used in mains 400-600 mm diameters.

Distribution

There are 650 kilometers of pipe in the distribution system. The sizes range from 100 to 300 mm. About 90 percent of the pipe is cast iron. There are 10 kilometers of cement asbestos pipe. There are 5000 fire hydrants in the system, 80 percent of which are of which are of the underground type. There are about 15,000 valves in the entire system. All services are metered. The standard meter used is of the disc type with internal parts and gears of bakelite. The average life of household meters was reported to be 10 years with general repairs and inspection every second year.

Storage

The largest storage tanks in the city are at Kratzenberg (6,750m^3) and West End (2,140m^3). They are covered tanks of reinforced concrete construction. The Bergstrasse tank was visited. The reservoir is in two sections each 1500 m^3. It is located in a fenced off area in a woods, covered and well concealed. The use of white tile is very effective in the general appearance of the reservoir. The layout of piping and access galleries was impressive and of good design.

War Damage

There have been 500 breaks in the water transmission and distribution system since September 1944. One bombing raid in that month broke most of the large mains and the city was without normal water supply for several weeks. The intensive bombing of March 1945 prevented normal water service to 80% of the city. Emergency measures taken consisted in distribution of water at central supply points, using pipe and hose laid over the streets. Residential areas were also supplied water in barrels and gasoline containers.

Items of Special Interest

The use of substitute materials in well casings, screens, and water meters; the iron and hydrogen sulphide removal plant at Tränkweg; and the layout and protective features of the underground storage reservoirs were the most interesting features of this plant. The plants appeared to be well maintained and under good technical supervision.

TARGET A-5

Name: Essen Water Works System

Location: Essen and vicinity

Persons Interviewed: Dr. Ing Bach, Director Water Dept.; Arnold Kegel, City Engineer

Interviewed by: A. E. Gorman

INFORMATION OBTAINED

General

Essen is the principal city in the highly industrial Ruhr area. In 1940 its population was 700,000; at the time visited it was estimated that not over 320,000 people were living there. The city was very heavily bombed and the destruction of property in the central commercial and industrial areas of the city--especially in the vicinity of the great Krupp Works--was intensive. Destruction of residential property within the city was also very heavy.

Before the war 120,000 m^3 of water per day was supplied from the city system or 172 liters (45.5 gallons) per capita. Consumers also purchased 40,000 m^3 from private systems in the suburbs. The Krupp Works provided its own water, but its system was cross connected with the city supply for mutual service in case of emergency. The estimated quantity of water being supplied by the city system at the time of inspection was 50,000 m^3 per day.

Source of Supply

The city has three water supply and pumping stations:

Station	Normal capacity m^3 per day
Spellenberg	100,000
Steele	15,000
Kupferdreh	5,000

All water is either Ruhr River water which has naturally percolated through the sand and gravel underlying the area on either side of the river or it may be river water which has been filtered through open sand filters constructed in basins adjacent to the river. These filters of various shapes and sizes to cover the developed area are often built in land, below river level, which has settled because of coal mining operations; in such cases they are filled by gravity flow direct from the river, otherwise pumping from the river is necessary.

Water is obtained from these natural percolation beds or artificial filters through collecting pipes laid approximately 50 m horizontal distance from the river or the filters. (See Fig. A-5-a-b-c) These are perforated concrete pipe, 800 mm in diameter, laid at a depth of 10-11 m and surrounded by coarse gravel. These pipes lead to a central well from which the water is pumped to the storage and/or distribution systems.

Treatment

The natural cleaning of the river water in the course of its filtration is so thorough that the water from the collecting wells is usually fit for immediate drinking. The artificial filters are concrete walled filter basins which have been dug through the clay of the river valley floor to the underlying gravel. The bottom of these basins is covered with a 2.0 m layer of sand which overlies a base of prepared stone or gravel. The sand size is about 1.0 mm. There are 16 filters having a total area of 100,000 m^2.

The rate of filtration varies widely depending on the condition of the river and the amount of water reaching the collecting system by natural underground flow and penetration from the river. Filters are cleaned by ranking the "schmutzdecker" in piles and removing it. New sand is put in the upper section of the filters about twice a year. Normally the water is chlorinated after filtration. The chlorine solution is applied in the well from which the pumps take suction. The average amount of chlorine used is 0.125 ppm.

Pumping

At the Spellenburg station there are three steam turbine driven centrifugal pumps, two of 36,000 and a

third of 24,000 m^3 per day capacity. Two steam engine and fly wheel driven reciprocating pumps are held in reserve; one is horizontal and has a capacity of 18,000 m^3 per day, and the other is vertical and has a capacity of 41,000 m^3 per day. The water pressure at the pumps at this station is 12 atmospheres or 176 pounds per square inch.

At the Steele plant, which supplies the eastern section of the city and also the villages of Steele, Frellendorf, Stoppenberg and Schannebeck, there are three steam engine flywheel driven horizontal reciprocating pumps with capacities of 12,000, 6,000 and 6,000 m^3 per day respectively.

Storage

Water is pumped to six underground concrete storage reservoirs having a total capacity of 13,500 m^3. They vary in size from 150 to 7,000 m^3. There are in addition five elevated tanks on stone and brick towers, with capacities varying from 600 to 1,500 m^3, and a combined storage capacity of 5,100 m^3.

Distribution

The Essen system has approximately 1,000 kilometers of pipe in its water distribution system, 95 percent of which is cast iron. Most of the remaining pipe is steel. The diameter of these pipes ranges from 100 mm to 800 mm; about 75 percent is in the 100 and 150 mm size.

There are about 2,000 fire hydrants, all but five of which are of the underground type, spaced at 500 meters in the residential area and 200 meters in the three commercial and industrial areas. There are approximately 10,000 valves in the system.

Quality

The water as delivered to the consumer has 80-100 ppm hardness, mostly bi-carbonate. The CO_2 content is 15-20 ppm. It contains negligible amounts of manganese. The pH ranges from 7.4 to 7.6. At the Spellenburg plant there is a small chemical and bacteriological laboratory where tests are made daily. The health department collects

samples regularly from the distribution system for bacterial analysis. Considering the larger number of breaks in water and sewer pipes throughout the city and the amount of repair work which was in progress, the amount of chlorine being used to treat the water at the time of inspection was considered to be low for adequate protection of the public health.

War Damage

The intensive bombing of Essen brought great destruction to public utilities. Following the bombing of March 11, 1945, there was an area in the principal commercial, industrial and residential sections of the city, comprising 2500 acres, in which there was no normal supply of water for eight days. The only water available to the citizens was that pumped from emergency sources and distributed at water points through hose and pipe laid over ground or transported in tanks. In this area there were 80,000 dwelling units.

There were about 2,000 breaks in the city water distribution system. Sewers and water mains were often broken in the same bomb crater and repairs were most difficult. (See A-5-d) It was estimated by city officials that two percent of the entire distribution system was destroyed. (See Fig. A-5-e) By April 15, 660 breaks had been repaired. Citizens in many areas were carrying water from water points established by connecting a household faucet to a riser pipe attached to an underground hydrant. (See Fig. A-5-f)

There were 18 breaks in major pipe lines 200 to 800 mm in diameter. These prevented supply to the system from the pumping stations. Seven bombs hit the filters adjacent to the river, and two units had to be reconstructed. Damage to pumping equipment was minor. The principal elevated storage tank in the center of the city was destroyed. (See Fig. A-5-g) Two bombs crashed through the roof of the larger adjacent underground storage reservoir. (See Fig. A-5-h)

Items of Special Interest

The Essen water works offered little of special target value from the point of view of equipment or operating practices which would be especially useful to American or British water works officials. The intensive destruction of facilities shown in the illustration are of interest since they show how vulnerable water works are to aerial bombing.

TARGET NO. 6

Name: Ruhrverband

Location: Headquarters, Essen

Dates Visited: June 20, 28, 30, 1945

Persons Interviewed: Drs. Franz, Fries, Sierp, Bucksteeg

Interviewed by: Fischer, Lt. Col. Gilbert, Gorman, Sheridan

INFORMATION OBTAINED

General

The two Ruhr River associations, the "Ruhrverband" and the "Ruhrtalsperrenverein" are organized under Reich legislation and are responsible for water supply of the Ruhr industrial area where there are large coal and iron industries and in which district about 4,000,000 people reside. Water supply for public use is from the Ruhr river collected from wells and infiltration galleries by about 90 different water works systems owned by municipalities and industries.

The use of water by the district exceeds the dry weather flow of the Ruhr and its tributaries so that the "Ruhrtalsperrenverein" has constructed numerous dams and reservoirs to conserve and regulate the run-off for effective use. At several places it produces power from the water which is released from these reservoirs. The "Ruhrverband" is responsible for keeping the Ruhr River in such condition that it is usable as a source for water supply. Each community constructs and maintains its own system of sewers, but the Ruhrverband constructs and operates and maintains such collecting sewers and sewage treatment works as are necessary to meet this responsibility. Usually industrial plants construct and operate their own waste disposal plants for industrial waste under the direction and after consultation with the officials of this organization. The impounding reservoirs built by the Ruhrverband effect considerable biological purification of the river waters.

The works of these organizations--dams, bridges, interceptive sewers and sewage and industrial waste treatment plants--were seriously damaged as a result of war activities.

Items of Special Interest

Interrogation of these men revealed the fact that the most interesting plants to visit from the point of view of water treatment were those of the cities of Essen and Hagen which are reported on as Targets 5 and 7.

The principal concern of the district was over the excessive pollution of the Ruhr River following destruction by bombs and German demolition of trunk sewers in the Hagen area and in the lower stretches of the river between Essen and Duisberg. As a result of this damage, raw sewage and industrial wastes were being discharged into the river, placing pollutional loads on water purification systems far in excess of what they were designed to take care of to protect the public health.

Ruhrverband Universal Indicator

Perhaps the most interesting items of recent technical value reported by the chemists of the Ruhrverband was the development of a "universal" indicator for determining pH values and the equipment for making the colorametric tests for these values. The indicator was developed by the late Dr. F. Fransemeir and an assistant at the Ruhrverband laboratory. It has a pH range from 0.1 to 14.0. The equipment used in making the test is known as the Ruhrverband Comparator and is manufactured by W. Feddeler, a manufacturer of scientific apparatus in Essen (see Figures A-6-a and b).

It was alleged that the indicator was manufactured by a secret (German patent) process and that only Dr. Fransemeir and his daughter knew the constituents and the method of preparation. An interview with the daughter who is a prisoner of war held by the American Army in Chalaus sur Marne, France, developed that while she helped her father prepare the indicator she did not know all the constituents nor the relative amounts of

each. Chemists and the Ruhrverband laboratories (Dr. Sierp and Bucksteeg), and the lessee Feddeler claimed they did not know all the constituents of the indicator. Those which were reported as used were: methol red, methol orange, bromthymol blue, and phenolphthalein.

A sample of the indicator was obtained for analysis.

The apparatus consists of a case fitted with three sight glasses, three test tubes and three sets of color slides, each representing a pH value, and it is operated much the same as similar comparators manufactured by other companies. The colors of the slides corresponding to pH values from 0.1 to 14.0 are as follows:

pH Value	Color	pH Value	Color
0.1	Deep pink	8.0	Light green
1.0	Lighter pink	8.5	Green-blue
2.0	" "	9.0	Blue-green
3.0	" "	9.5	Blue-purple
4.0	" "	10.0	Deep purple
5.0	" "	10.5	Lighter purple
5.5	Yellow	11.0	" "
6.0	Lighter yellow	12.0	" "
6.5	" "	13.0	Purple blue
7.0	Yellow green	14.0	Blue
7.5	Green		

TARGET NO. A-7

Name: Hagen Water Works

Location: (1) Hengstey, (2) Haspetalspeer

Date Visited: June 20, July 4, 1945

Person Interviewed: Albamo Imaker, assistant director

Interviewed By: Fischer, Lt. Col. Gilbert, Gorman, Sheridan

INFORMATION OBTAINED

General

Hagen is an important industrial city in the Ruhr district about 22 miles southeast of Essen. It has a population of about 150,000. It suffered heavy damage from 20 air raid bombings during the war. The water works is municipally owned. The average normal water use per day is about 40,000 m^3 or 70 U.S. gallons per capita. About 50 percent of the water is used for industrial purposes. At the time of this inspection the amount of water being supplied to the city had been reduced to 30,000 m^3 per day because of the shutdown of industrial plants.

This water system was a special target value because of the variety of methods of treating the water and the combinations of old and modern equipment used. The Hagen facilities may be said to be typical of the old and the new in water supply in the Ruhr valley.

Sources of Supply

All water has its origin from the Ruhr River. There are two principal plants, the Hengstey and the Haspetalspeer. Normally, about two-thirds of the supply is furnished from the former source and one-third from the latter, but this varies widely depending on conditions in the river or at the plants.

Water is obtained at the Hengstey plant by two methods: (1) natural infiltration from the Ruhr River into large collecting galleries, and (2) from wells penetrating a natural water bearing strata which is artifically recharged by river water filtered through slow sand filters, and if these sources do not produce enough water then the rapid sand

roughing filters are put into operation. This is normally necessary only during 3 or 4 months in the late summer and fall when rainfall may be low and the algae content in the river water high.

The natural infiltration system consists of a long gallery of perforated concrete pipe 800 mm in diameter, laid at a depth of about 7 mm, and surrounded by gravel. This gallery, which has a total length of 650 m. is in three sections and has four collecting basins. It is about 60 m. from and parallel to the river. There are three lines of wells in the well field, with 19, 17 and 8 wells respectively, in each. Well spacing is from 100 to 110 meters. The cast iron collecting pipes vary in diameter from 700 mm to 300 mm. Withdrawal from the 8 recently constructed wells is by air lift, and from the others by vacuum or gravity. At the time of inspection, water was being withdrawn from both sources about 20,000 m^3 per day.

Treatment

There are 7 slow sand filters and one percolating filter used to charge the well field supply. The slow sand filters are from 20 to 28 m. wide, approximately 125 m. long, or a total area of 29,200 m^3, and 1.0 m. deep. The sand size is 1.0 mm. The filters are built in pairs on either side of a row of wells so that one is always in service while the other is being cleaned. The average distance from the midpoint of either one of a pair of filters and the row of wells is 85 m. The area of the filters is summarized below:

Filter No.	Area in m^2
1	3000
2	3000
3	3600
4	3600
5	This is the percolating filter
6	3600
7	7200
8	5200
Total	29,000 = 7.2 acres

The rapid sand filter plant, total area 106 m^2, is the BAMAG type which has a rated capacity of 850 m^3 per hour (5,400,000 U.S. gals. per day). (See Fig. A-7-a). There are 8 filter units with 2 filters (5.3 x 2.5 m.), to a unit. The depth of the sand is 1.5 m. over 0.5 m. graded gravel. They are built 4 units on each side of a central operating and pipe gallery. (See Fig. A-7-b).

The filter plant is also equipped to use aluminum sulphate as a coagulant if necessary. There is no preliminary settling of the coagulated water. Mixing of the river water and coagulant is effected in a basin in which a series of wooden paddles attached to two vertical shafts rotate in opposite directions, the paddles on each shaft being so spaced that they clear those on the other shaft. (See Fig.A-7-c). The mixing time is about 10 minutes.

This plant is compact and well arranged. Filters are backwashed with air and water.

All water is treated to reduce CO_2 in order to prevent pipe corrosion before being pumped to the city. The treatment is with hydrated lime by the Bücher system, using two Bamag-Meguin automatic treatment units. (See Fig.A-7-d). Chlorine at a rate of .2 ppm is applied to the water as pumped to the city.

The second source of supply is at Haspetalsperr, about 15 miles from the Hengstey plant where a masonry dam across the Ruhr River forms a reservoir which has a capacity of two million m^3. The plant normally supplies 20,000 m^3 per day but at the time of this inspection it was being operated at one-half this rate. This water must be filtered because of algae growths, intermittant pollution on the watershed, and turbidity. It is delivered by gravity to the filter plant through a steel conduit 600 mm in diameter. The filter plant is the standard WABAG design, see Fig. A-7-e), which is operated intermittantly as needed.

This plant was put into operation in 1944. There are 6 filters, each with a filter area of 42 m^2 or a total area of about 252 m^2. It has a rated filtering capacity of 1200 m^3 per hour which would be about 2.0 U.S. gals. per sq.ft. per minute. Provision is made for alum and soda ash treatment. A hydraulic jump is used for mixing. There is no preliminary settling.

The filter sand is 1.5 m. in depth and the range of sand size is 0.8 to 1.0 mm. The sand is placed directly on the concrete slab filter bottom. The filter nozzles or strainers are of porcelain, spaced 100 mm on centers. Each strainer is integrally cast with a combined air and water inlet pipe which passes through the slab.

Filters are washed at 2½ feet loss of head and the average time between washes is 4 days. Wash water is settled and the supernatent liquor is discharged to the creek.

The water from the filtered water storage reservoir flows by gravity to a Bücher system CO_2 removal plant where it is treated with a saturated solution of slaked lime as at the Hengstey plant. Chlorine is applied by automatic or manual control. Flow to the city is by gravity.

This new plant is exceptionally well equipped and is operated under skilled technical control. Among its more interesting features are: (1) the general external and internal appearance of the plant, (2) the ample room for all equipment, (3) the hydraulic valves in the pipe gallery, (4) the filter control equipment, (5) the hydraulic jump for mixing, (6) the liberal spacing in the pipe gallery, (7) the automatic control of chemicals applied in proportion to flow, (8) the bakelite impellors and lining of chemical feed pumps, (9) the pressure filters for chemical solutions, (10) the wooden lining of concrete chemical mixing tanks, (11) the automatic chlorinators, (12) the location of chlorine storage and control equipment outside the building, (13) the wash water settling tank, (14) the continuous filter control tables, (15) the access gallery around the filters, (16) the absence of overhead lighting in the filter room, and (17) the use of yellow glass in the side windows to control algae.

Pumping

Pumps at the Hengstey plant are high pressure, horizontal reciprocating units. Two are driven by steam engines and a third by an electric motor. Their capacities are 24,000, 28,800 and 14,400 m^3 per day respectively. There is no pumping at the Haspetalsperr plant.

Transmission

Two cast iron mains, 400 and 500 mm. diameter, delivery of water to the city from the Hengstey plant. The size of the pressure line from the Haspetalsperr plant was not obtained.

Distribution

The city system contains about 60 kilometers of cast iron pipe ranging in size from 500 to 100 mm. The system has 12 storage tanks with total capacity of 6000 m^3. High areas in the system are served by 8 booster pumping stations with a total capacity of 500 m^3 per day.

Quality

The iron content in the water as delivered to the city is about 0.1 ppm. The CO_2 content after treatment is about 5.0 ppm. The Ph of the treated water varies from 7.5 to 8.5. The hardness is about 115 ppm, but this varies considerably depending on the condition of the Ruhr River.

War Damage

The most serious damage to water systems was to the two cast iron transmission mains from Hengstey to the city, both of which were broken by bombs. The larger was broken in 15 places and was not usable for 3 months. During this time, water was delivered to the city from Haspetalsperr. There were about 200 breaks in the distribution system. Repairs had to be made to approximately 5 percent of the system.

Items of Interest

The features of this system of special interest are: (1) the recharging of underground supplies by filtered water, (2) the two modern rapid sand filtration plants of BAMAG and WABAG design, and (3) the Bücher system for removal of CO_2.

TARGET NO. A-8

Name: Bremen Water Works

Location: Bremen

Date Visited: July 6, 1945

Persons Interviewed: Mayer, director, Gas and Water Dept., Husman, chief engineer

Interviewed By: Fischer, Gorman, Sheridan

INFORMATION OBTAINED

General

Bremen is one of Germany's large industrial and commercial cities. The city suffered heavily from war damage. Destruction of water supply facilities was the worst of its kind seen in Germany. About one-third of the city is in Neustadt on the south side of the Weser River where one of the major water plants is located. The water transmission lines were laid over the principal highway bridges. War destruction of these bridges seriously complicated water supply problems. In 1940, the city water system served 350,000 people. The normal supply of water was 46,500 m^3 per day or the equivalent of 35.0 U.S. gals. per capita. At the time of this inspection it was estimated that a population of 250,000 was being served and the amount of water supplied was 30,000 m^3 per day.

Sources of Supply

There are two major sources of supply: (1) the Kleine Weser River, with intake works in the city, and (2) surface water from the Hartz Mountains impounded about 220 kilometers south of the city. Water for both supplies is filtered, after which it is mixed in an underground storage reservoir at the Neustadt plant and re-pumped to the city. The distribution of water supplied from these two sources was as follows:

Source	Av. Supply in m^3 per day Year 1940	Jan.-July 1945
Weser River	31,500	15,000
Hartz Mts.	15,000	15,000
Total	46,500	30,000

The Kleine Weser is formed by a channel cut back from the Weser River. The water works intake is upstream from the city sewers and the water is generally of reasonably satisfactory quality for treatment. It is not affected by tidal influences. The water normally flows by gravity through two cast iron lines (1000 and 600 mm. diameter), to two interconnecting wells outside the low lift pumping station in Neustadt, from which it is pumped to the settling tank at the filter plant. When the river is low and gravity flow is not possible, water is pumped into the inlet lines by two centrifugal pumps set on a floating barge docked near the river intake.

The Hartz Mountain water is delivered to the filtered water reservoir at the Neustadt plant through a 450 mm. diameter reinforced concrete pipe line, and it can be supplied directly, but at reduced pressure, to the city system through a by-pass around this reservoir. This practice was followed during the war emergencies when the Neustadt plant was damaged. The supply from the Hartz Mountains to Bremen is limited to 15,000 m^3 per day, because of the commitments to other cities served by this system, but during war emergencies more than this supply was obtained from this source.

Treatment

Weser River water is pumped to two adjacent brick and concrete open settling basins having an average retention period of 24 hours. No chemicals are applied for coagulation. This basin is cleaned manually by squeegeeing and flushing the sludge to drains from which it is pumped to lagoons for drying.

There are 22 open filters of various sizes with a total surface area of 13,800 m^2 (3.4 acres). The normal filtration rate is 31,500 m^3 per day, the equivalent of 2.4 million (U.S.) gallons per acre per day. The depth of the filter sand is 2.5 m. varying in size from 0.1 at the top to 1.5 at the bottom. Cleaning is done by periodic removal of top sand and washing it in two Excelsior mechanical cleaners (see Fig.A-8-b). The period between cleaning depends on the condition of the river, ranging from 4 to 30 days.

The filtered river water mixed with the filtered water from the Hartz Mountain supply, is stored in an underground filtered water basin having a capacity of about 10,000 m^3. Chlorine is applied to the mixed water at the reservoir inlet to the high pressure pumps. Normally, .3 ppm of chlorine is used.

Pumping

There are 12 pumps in the two pumping stations at the Neustadt plant. Their type and capacity are summarized in the following table:

Pump No.	Power Source	Capacity in m^3 hour High Pressure	Capacity in m^3 hour Low Pressure
1	Steam	650	
2	"	1000	
3	"	1000	
4	"	500	
5	"		650
6	"		650
7	Electric	1000	650
8	"	1000	
9	Steam	400*	400*
10	"	400*	400*
	Total	5950	2100

* Combination High and Low Pressure systems

Transmission

Water was delivered to the main portion of the city from the Neustadt through five cast iron or steel mains installed on three bridges and through one steel main laid under the river. The destruction of these transmission lines, either by German demolition or British and American air force bombing, created one of the most serious problems faced by Bremen water works officials. Data concerning the lines and the cause of their damage is summarized in the following table:

Damage to Transmission Lines - Neustadt to Bremen

Location	Diam.mm.	Cause of Damage
Adolph Hitler Bridge	300	Bombing
" " "	300	"
Kaiser Bridge	600	Demolition of bridge
Leiditz Bridge	500	" " "
" "	200	" " "
Under Weser River	1000	Bombing

At the time of inspection two 300 mm. emergency steel pipe lines had been suspended on cables across the Leiditz Bridge, and a 500 mm. riveted steel line was being installed across a pontoon bridge recently constructed by the American Army.

Distribution

There are 1200 kilometers of pipe in the Bremen distribution system varying in size from 1000 to 100 mm. in diameter. About 50 percent are in the 150 and 200 mm. sizes. About 90 percent of the pipe is cast iron; the remainder is steel. Experimental sections of cement asbestos pipe had been used, but difficulty was reported because of damage where vibration was experienced.

There are 10,000 fire hydrants in the system, 1200 of which are of the above-ground type. In winter much difficulty is experienced with freezing of the underground hydrant covers. Director Meyer reported that the maintenance cost of the latter type was about 6 times that of the above-ground hydrants.

The normal pressure carried in the system is about 45 psi, but because of limited transmission capacity it was only about 20 psi, at the time of inspection and during periods of heavy consumer use it was much lower.

Storage

There are two elevated steel storage tanks in the distribution system. One, at the Neustadt filtration plant, is housed in the tower of the main pump station. It is 40m. high and has a capacity of 1800 m^3. The other, in the southern section of the city, is housed in a decorative structure elevated on a steel tower. It is 42 m. high and has a capacity of 3000 m^3. Each tank was out of service on account of bomb damage to its roof (see Fig. A-8-c and d).

Quality

The following tables give summaries of the bacterial, physical and chemical quality of samples of the water from the Bremen system collected in February 1945.

Bacterial Analysis

Date 1945	Sample from	Total Bacteria: per m/l 42°C - 48 hrs.	Coliforms per 100 m/l 37°C - 72 hrs
Feb. 6	Weser River, raw	19,200	10,000
6	" " settled	1,250	100
6	" " filtered	200	1.0
6	" " " and chlorinated	2	0
6	Hartz Mt. to reservoir	0	0
2	Mains - Weidenstrasse	8	0
2	" Schrocklausen Str.	6	0
2	" Kinderdruck	12	0

Physical and Chemical Analysis

Examination	Weser River Water - Raw	Mixed Filtered Weser River and Hartz Mt. Water
Odor	Sl.earthy	Sl. earthy
Color	Lt. yellow	Lt. yellow
Ph	7.75	7.0-7.5
Turbidity	20-35 ppm	10-15 ppm
Total Hardness	189 "	133 "
Carbonate "	76 "	50 "
Non-carbonate Hardness	123 "	83 "
Chlorides	294.2 "	191.0 "
Iron	.4 "	.15 "
Manganese	0	0

Water is collected at 10 points in the distribution system by the Health Department two or three times each week. Considering the large number of mains under repair and the low pressures in the system the bacterial analyses were surprisingly good.

War Damage

The Bremen water system suffered heavily from war actions, especially aerial bombing, during the period October 1944 to May 1945. The Neustadt filter plant, although extensively camouflaged, was seriously damaged. Camouflaging appears to have attracted bombers rather than diverted them. The plant, so close to the city, may have been mistaken for an industrial plant.

At the time of inspection, only 9 of the 22 filters were operable (see Fig. A-8-a). Damage to two other filters was not serious and it was expected that repairs could be made in about three weeks. The other 11 will require extensive rehabilitation of walls and underdrains. The wall of one of the settling basins was seriously damaged and only one basin was in use. One of the filtered water basins could not be used because it had a large bomb hole through the roof and one of the side walls was seriously damaged.

The pumping station equipment, with the exception of two units, was not seriously damaged. Several pumps were not operable because of the debris which had fallen onto moving parts from damage to the tower building housing the pumps.

It was estimated that the 1200 breaks in the distribution system will require replacement of about 162 kilometers of pipe or 1.33 percent of the system. In order to operate the system, 70 kilometers of mains or 6.4 percent of the system had to be taken out of service because of breaks. Water works officials estimated that two years will be required to repair this system and to restore normal service.

Item of Special Interest

The Neustadt plant and pumping station is old and has no equipment of special interest. The extent to which a water works with exposed filters and transmission lines on bridges is vulnerable to aerial bombing was most effectively demonstrated in Bremen.

TARGET NO. A-9

Name:	Hartz Mt. Water Supply (Hartzwasserwerke der Province Hannover)
Location:	Headquarters - Hildersheim; Filter Plant - Osterode
Date Visited:	July 9, 1945
Persons Interviewed:	Liemke, technical director; Heinsen, director, Filtration Plant
Interviewed By:	Fischer, Gorman, Sheridan

INFORMATION OBTAINED

General

This water supply system is maintained and operated to furnish water from the Hartz Mountains to cities and villages in the province of Hannover. Two dams have been constructed behind which the run-off from watersheds in the mountains is impounded. One, the Sösetalsperre - supplies the cities of Osterode, Hildersheim, Neustadt, Nienberg, Syke, Bremen and intermediate villages. The other, the Eckertalsperre, serves Brunswick and the cities in that area. Only the former was visited, primarily because of its service to Bremen. The water is collected, purified and delivered to the respective cities, each of which operates its own water works system. The Sösetalsperre has a capacity of 25, and the Eckertalsperre 13 million cubic meters.

Source of Supply

The Söstalsperre is about 5 miles east of Osterode. It was built in 1933, and has a watershed of 48 square kilometers or about 30 square miles. At the time of our visit, about 17 million cubic meters were in storage behind the stone door. Water is delivered by a steel pipe to the filter plant a short distance below the dam. In the drop of 45 meters power is developed in two hydroturbine generators of 1200 and 150 Kw capacity.

Treatment

The output of the filtration plant is 45,000 m^3 per day. The water is treated with aluminum sulphate (av. 1.5 gr/gal) and soda ash (av. .9 gr/gal). Mixing takes place in and around the end basin with 3 passes.

There are 5 WABAG double pressure filters used as roughing filters ahead of the rapid sand gravity filters. They were built in 1938, when additional output from this plant became necessary. They are used when the water is turbid or when the condition of the reservoir water is such that the output from the rapid sand filters cannot meet requirements. They are 1.5 m. in diameter. Sand depth is 1.0 mm. in each filter. Wash is by air and water. The control is automatic from an operating table in the gallery. Pipe lines to and from the filters are identified by distinctive colors. Valves are operated hydraulically. Rate of flow and loss of head recorders are provided. There are 7 rapid sand (WABAG) filters, each of 48 $m.^2$ surface making a total of 336 m^2 (3600 sq. feet). When 45,000 m^3 of water is filtered the rate is about 2.35 U.S. gallons per square foot per minute. The sand depth is 1.5 m. and the sand size .6 to 1.0 mm. There are 5000 porcelain strainers per filter or 103 per square meter, compared with 90 at the Buna Water Works in Schkopau. If the roughing filters are in operation, these filters are washed about every 12 days. The filters are built on one side of an operating gallery equipped with operating tables and hydraulically operated valves, rate of flow recorders and loss of headguages. The filtered water is treated with milk of lime to eliminate CO_2 and as a protection to the steel transmission line. The process used is the Bücher system similar to that at Hagen.

A very interesting feature of this plant was the use of an intermittantly operated photo-electric cell for recording turbidity in the filtered water. Water from each filter is passed before the cell at about 10 minute intervals. The operation of the control valves to the apparatus and for flushing the lines, is automatic. The turbidity is recorded on a time chart. There is a sight well 4 m. deep into the white tile lined clear well by means of which the operator may observe the condition of the filtered water. The water is chlorinated as it leaves the clear well to the transmission main. The average amount of chlorine used is .2 ppm. All important operating records at the plant are automatically recorded.

The plant is well maintained. Research had been conducted to determine the effectiveness of phosphate salts in the prevention of corrosion of steel pipe, but they were discontinued because of war conditions.

Transmission

The transmission line from the reservoir to the terminal at Bremen is about 193 kilometers in length. The pipe line is of steel in the following lengths and diameters:

Size of Hartz Mt. Transmission Line - Osterode to Bremen

Length Kilometers	Wall Thickness mm.	Diameter mm.
23.0	9	800
24.0	8	700
11.2	8	700
28.8	9	600
93.0	7	575
13.0	7	450
193.0		

The drop in elevation from Osterode is 264 meters. There are four enclosed reservoirs along the route of the line at which pressures are controlled. These stations are Ackenhausen, Petzr, Benthe and Holterheide. The branch lines to the communities served are mostly cast iron pipe. The normal operating pressure at the Bremen outlet is about 30 pounds per square inch. The maximum capacity of the line to Bremen is 19,200 m^3 per day.

Quality

The following is a summary of the physical, chemical and bacteriological quality of the water from this source as sampled on February 22, 1945:

Analysis For	Raw Water	Filtered Water
Color	6.0	2.0
Temp O_C	3.6	3.4
Turbidity (2 mm.)	62.0	22.0
Ph	6.7	9.5
Carbonate hardness (U.S.)	5.0 ppm	10.0 ppm
Non-carbonate hardness (U.S.)	10.0 "	11.0 "
Total hardness (U.S.)	15.0 "	21.0 "
Free CO_2	4.0 "	0
Combined CO_2	4.0 "	8.0 "
Nitrates	1.8 "	1.7 "
Iron	.08 "	.01 "
Manganese	.07 "	.03 "

Analysis For	Raw Water	Filtered Water
Bacteria per m/l 22°C 48 hrs.	90	1.0
Gas formation 100 m/l 37°	+	-
" " 10 " "	-	No test
" " 1.0 " "	0	" "
Coliform confirmed	0	" "

At the filtration plant there is a well-equipped bacterial, chemical and plankton laboratory. Samples are collected twice each day.

War Damage

The plant and service facilities were not damaged during the war. The principal war impact on the system was the requirements of special service to the city of Bremen when the Weser River plant was damaged. Delivery rate to the city was then increased to the maximum capacity of the line.

Items of Special Interest

The system was of interest for several reasons: (1) the service to a series of communities which otherwise could not afford to construct the necessary works to bring the high quality surface water to them, (2) the development of power from the available head from the reservoir to the treatment plant, (3) the use of pressure roughing filters preceding rapid sand filters, instead of using settling basins, (4) the extensive use of automatic recording instruments, and (5) the intermittant use of a photo-electric cell for determining and recording turbidity in the filtered water from each unit.

TARGET NO. A-10

<u>Name</u>: Berlin Water Works

<u>Location</u>: Tegel - Berlin

<u>Date Visited</u>: July 23, 27, 1945

<u>Persons Interviewed</u>: Stegler, director; Alsdorf, asst.dir.

<u>Interviewed By</u>: A.E.Gorman, Maj.P.L.Hamilton

INFORMATION OBTAINED

General

The visits to water works targets in Berlin were made in connection with a special mission to assist the Utilities Section of the Production Control Branch, G-4, to prepare estimates of fuel and power requirements to operate the water works of that city during the subsequent year. The public utilities of Berlin are integrated systems operated and controlled to serve the entire city. Therefore, service could not be subdivided by the various zones of occupation of the Allied Commission. It had been agreed by the officials of the American, British and Russian armies that the respective utilities systems; power, gas, water and sewers should continue to be operated as city-wide units, and that coal and power requirements should be agreed upon and be furnished on a pro-rata basis.

In cooperation with the army officials the TIIC Public Utilities team assisted in making these estimates. It was therefore possible to visit several of the large water works plants, but time did not permit a complete study of the system. For this reason the target reports are limited in scope largely to the water supply and treatment facilities of these units in the Berlin system.

The public water supply system for Berlin is municipally-owned and is a combination of the Berlin City Water Works and a former private company, the Charlottenburg Water Works (see Fig. A-10-a). The city system has 14 sources, each with its pumping station. In addition, there are 3 high pressure pumping stations. The latter system has 3 sources, each with its own pumping station. All water is obtained from wells except that at the Fredrichshager station where well water is supplemented by water from the Muggelsee.

In 1940, these systems supplied 4,300,000 persons with about 650,000 m^3 per day or 150 liters per capita (39.5 H.S. gals). The maximum production of this system is 1,220,000 m^3 per day. Many industrial plants in Berlin have private wells and do not use the public supply. Under normal conditions the use of water by industries from these sources is approximately 80,000 m^3 per day.

The capacity of the various units in the Berlin water works system are summarized in the following table:

Capacity of Supply and Pumping Stations
Berlin Water Works System

Name of Plant	Capacity m^3/day
Jung Fernheide	83,000
Spandau	31,000
Kladow	8,500
Tempelsee	12,500
Eichwalde	15,000
Tegel	208,000
Fredrickshagen (Müggelsee)	294,000
Treftweg 1 and 2	30,000
Wuhlheide	77,000
Rahnsdorf	10,500
Köpenick	11,500
Alt-Glienicke	5,000
Kaulsdorf	31,000
Stolpe	80,000
Trefwerder-Rupenham	65,000
Johannisthal	100,000
Beelitz-Hikolassee	160,000
Total	1,222,000

High Pressure Pumping Stations

West End	48,000
Kleistpark	64,000
Lichtenberg	298,000
Total	410,000

The transmission mains from these stations to the distribution system are of steel and cast iron and vary in size from 1000 to 250 mm. in diameter. Cast iron pipe is used principally in the distribution system. Pressures in the system range from 40 to 60 psi. The transmission and

distribution system in the central section of the city was seriously damaged and several stations were unable to operate. Damage was especially heavy at river and canal crossings where pipe on bridges had been destroyed. Time did not permit collection of data on the damage to these systems.

TARGET NO. A-11

Name:	Berlin Water Works - Tegel Plant
Location:	Tegel
Date Visited:	July 26, 1945
Persons Interviewed:	Dir. Rainan; asst. dir. Alsdorf
Interviewed By:	A.E.Gorman, Maj.P.L.Hamilton

INFORMATION OBTAINED

General

This plant is located on the east side of Tegelsee in the northwest section of the city. It supplies about 25 percent of the water to the Berlin system, and is operated in conjunction with the other ground water systems on the west side of the city and in Charlottenburg. Normally it supplies about 135,000 m^3 of water per day. The plant was not damaged by war actions and appeared to be well managed and reasonably well maintained.

Sources of Supply

Water is obtained from 304 wells around the shore of the lake. Their depth varies from 35 to 68 meters depending on location. Water is drawn from the wells under partial vacuum (96 cm.) and is collected in central wells through cast iron pipe varying in diameter from 910 to 1200 mm. In the case of the wells across the lake at Saartwinkle there is re-pumping to the Tegel station.

Pumping

The low lift station for pumping water from the wells to the aerators, has 4 Borsig vertical triple expansion engines, each driving a pump of 32,000 m^3 per day capacity. The high pressure station has 8 centrifugal pressure pumps which deliver filtered water to the system. Four, driven by steam turbines, have capacities of 55,000 m^3 each, and four, driven by electric motors have capacities of 79,000 m^3 each. Two turbine and one motor driven unit are normally operated during the day. Because of the shortage of coal in Berlin, two motor driven pumps were being operated at the time of inspection.

Treatment

Treatment is for iron and manganese removal. It consists of aeration, settling, and slow sand filtration. The filters are covered and in two units. One unit consists of 8 filters, each being a segment of an octagon with an open area in the center. The other unit consists of 7 rectangular filters. It was reported that the latter filters are more satisfactory in operation.

There are 3 aerators each enclosed in a separate brick building (see Fig. A-11-a). The water enters in 10 elevated shallow basins of concrete construction from which it overflows in down pipes to the brick aerators below. The bricks are stacked with open joints and are cleaned by removal, air drying and brushing.

The aerated water is collected in a receiving basin under the filters and then flows to pre-filter settling basins for removal of as much iron as possible before filtration. The average settling period is about two hours. The filters have a total area of 35,800 m^2. Their normal output is 135 m^3 per day.

The sand depth in the filters is 1.2 m. In the upper half of the bed, the sand size varies from .25 to .75 mm. In the lower part the sand size increases until at the bottom coarse gravel is used as a foundation. Filter runs vary from 2-4 weeks.

The sand is cleaned in Excelsior mechanical sand cleaners. The ratio of water to sand used in cleaning is 6 to 1. Belt conveyors are used for transporting the sand. Removal from and return to the beds is manual, using shovels and wheelbarrows.

The filtered water is chlorinated, using .6 ppm. chlorine. Normally chlorine and ammonia are used in order to maintain residual chlorine throughout the distribution system. The ratio of chlorine to ammonia is 2 to 1. Hourly residual chlorine tests are made using otho-tolodin.

Quality

The following is a chemical analysis of samples of raw and treated water at this plant collected July 10 and 14 1945:

Item	Well Water	Filtered Water
Tempo° C	10.6	10.9
Ph	7.5	7.4
Total hardness (U.S.)	-	126.0
Carbonate " " "	102.0 ppm	106.0 ppm
Iron	2.73 "	.02 "
Chlorides	411.0 "	36.0 "

The bacterial analysis showed the water to be free of gas formers in 10 and 100 ml. amounts planted in lactose broth. Bacterial counts at 22° C, after 48 hours incubation were 5 per ml. and less.

Items of Interest

Interesting features at this plant were: (1) the brick aerators, (2) the pre-filter settling basins, (3) the slow sand filters, and (4) the method of chlorination. Of special interest was the relatively high amount of chlorine used (0.6 ppm) as compared with other plants visited where ground water supplies were filtered. Chlorine and ammonia are used in the ratio of 2 to 1 instead of 4 to 1 as is customary in the U.S. The chemist explained that in Berlin, experience had indicated that this gave the most satisfactory results in preventing consumer complaints with the relatively high quantity of chlorine used. Residual chlorine in the distribution system varies from .4 to .1 ppm.

TARGET NO. A-12

Name	Berlin Water Works - Friedrickshagen Plant
Location:	Friedrickshagen - Berlin
Date Visited:	July 24, 1945
Persons Interviewed:	Stepler, dir.; Hume, chief engineer
Interviewed By:	A.E.Gorman; Maj. P.L.Hamilton

INFORMATION OBTAINED

General

This plant is located in the southeastern section of the city on the north shore of the Müggelsee. It has a capacity of 294,000 m^3/day, and is the largest source of supply in the Berlin system. The water is obtained both from an underground well supply and directly from the lake. At the time of inspection, one-half of the water was being obtained from each source but normal practice is to supply only one-third from the lake. The plant itself was not damaged during the war, but its normal operation conditions have been altered because of shortage of coal and damage to the transmission system into which it pumps.

The following table summarizes pumping from these sources under normal and present conditions:

Friedrickshagen Water Supply m^3 per day

Source	Capacity 1939	Normal 1939	Average July 1945
Wells	250,000	123,300	81,500
Lake	125,000	61,700	81,500
Total	375,000	185,000	163,000

Sources of Supply

There are 3 principal well fields with a total of 370 wells. The depth of the wells varies from 40 to 50 meters, and they are spaced about 25 meters apart. The wells are operated under a vacuum. Water withdrawn flows through cast iron collecting mains 300 to 1200 mm. diameter, and discharges

to 3 central collecting wells from which it is pumped. The discharge casing from the wells is cast iron; screens in all wells, excepting those constructed during the war, are of copper and are from 5 to 15 m. in length. Ceramic well screens were used in recent years. No difficulty has been experienced with draw-down of the ground water elevation.

Pumping

The number, type and capacity of the low lift pumps are summarized in the following table:

Low Lift Pumps - Friedrickshagen Plant

Station	Source	Units	Type	Power	Capacity m^3/day
A	Wells	3	Reciprocating	Steam	36,000
B	"	6	"	"	36,000
C	Lake	3	Centrifugal	Electric	51,200
	"	2	"	"	28,000

Filtered water is pumped to the Lichtenberg station where it is repumped to Berlin (see Fig. A-12-a). The high pressure pumps normally pump against a head of 30 meters through 3 cast iron transmission lines, two 1200 and one 110 mm in diameter. At the time of inspection, however, only the 1100 mm line was operable because of damage to the other two; and, therefore, pumping was at a head of 42 meters.

The number and capacity of the high pressure pumps at this station are:

Pump No.	Power	Type Pump	Capacity m^3/day
1	Diesel eng.	Centrifugal	36,000
2	" "	"	72,000
3	" "	"	72,000
4	" "	"	36,000
5	Electric motor	"	72,000
6	" "	"	36,000
7	" "	"	50,400
8	" "	"	103,200
9	" "	"	24,000
10	" "	"	24,000
11	" "	"	24,000

These pumping stations were well maintained and the equipment appeared to be in good operating condition. The diesel engines are used for emergency power when there are

interruptions in electric power. There are automatic recording units for pressure and flow from each unit and similar equipment for electrical operating equipment.

Treatment

Water is pumped to 3 aerator buildings in each of which there are 10 shallow concrete basins for distributing the water through vertical outlet pipes to the brick aerators as at the Tegel plant (see Fig. A-11-a). The area of each basin is 50 m^2 or 1500 m^2 total. The water is collected in the basins under the aerators and flows to the settling basin. The aerated lake water is settled in 8 covered reinforced concrete basins. No coagulants are used. The settling period is from 3-4 hours.

There are 34 covered slow sand filters, each with an area of 2330 m^2, or a total of 79,220 m^2 (see Fig. A-12-b). Twenty-three filters are used for the lake water and the other 11 for the well water. The filters are 1.2 m. deep. The sand size in the upper 50 percent of the bed is under 0.5 mm. In the next 25 percent of the filter it is under 1.0 mm. Gravel at the bottom is from 2-6 mm. in diameter. Sand is cleaned at periods ranging from 2-4 weeks. It is transmitted by belt conveyor to the Excelsior sand washer, and is stacked for drying in the court around which the filters are built. About two inches of sand are removed for each cleaning.

The water is chlorinated by manual and automatically controlled units. The latter were out of order. The amount of chlorine applied varies from 0.6 to 1.0 ppm, and the chlorine solution is applied as the water enters the filtered water storage reservoir. Residual chlorine tests of the water are made hourly. The amount carried in the water pumped from the plant is 0.2 ppm.

Storage

The filtered water is mixed and stored in two concrete covered reservoirs having a total capacity of 30,400 m^3

Quality

Following is a summary of chemical analysis of the water at this plant sampled on July 21, 1945:

Item	Well Water		Lake Water	
	Raw	Filtered	Raw	Filtered
Ph	7.5	7.8	7.7	7.5
Carbonate Hardness (U.S.)	123 ppm	129 ppm	76 ppm	59 ppm
Iron	.15 "	0	.15 "	0 "
Manganese	No tests		No tests	

Bacterial and microscopic analyses are made daily in a well equipped laboratory at the plant. The filtered water is of good quality.

Items of Interest

The most interesting units of this plant are the pumping stations with their variety of power - steam, electricity and diesel engines. The station is well laid out, the equipment is in good condition and appeared to be well maintained.

TARGET NO. A-13

Name:	Fabrick Ebenhausen fur Gesell Chemische Erzenugnisse
Location:	6 miles southeast of Ingolstadt
Date Visited:	August 1, 1945
Person Interviewed:	J.Meidel, engineer

INFORMATION OBTAINED

General

This was one of many well camouflaged explosive manufacturing plants constructed by the Germans. It was built in 1938, and was enlarged progressively until 1941. About 2000 persons were employed, many of whom were housed in the vicinity and were supplied water from the drinking water system at the plant. The layout and design of the filter buildings was such as to give them the appearance of residences.

Sources of Supply

Water for the drinking water system was obtained from 5 wells constructed along the Parr River, each about 12m. deep, and with a capacity of 2160 m^3 per day. Screens were of galvanized iron. The industrial water was obtained from the river and settled about 12 hours in settling basins formed by excavation and having direct inflow to them from the river. The settled water flowed through 4 cast iron pipes to a central well from which it was pumped to the treatment plant by 4 vertical motor driven centrifugal pumps.

Treatment

Both the drinking and industrial water supplies were treated in BAMAG double-decked, vertical, pressure filters. (See Fig. A-13-a). Different coagulants were used; aluminum sulphate for the drinking water and ferric chloride for the industrial water. Both coagulants were prepared in double batch mixers with rubber lined tanks. Feed was to a constant level box, then by gravity through roto-meters on the discharge side of which a graduated glass receiver was set for calebration purposes. The measured coagulant solution flowed

by gravity through bakelite pipes to small electric driven centrifugal chemical feed pumps which delivered the solutions into the supply line to the filters. The pumps were lined with a synthetic chemical similar to bakelite.

The application of the ferric chloride solution was intermittent and the control was made automatic by the use of solenoid operated valves.

The double pressure filters for each water treatment plant were housed in a special house, designed externally to have the appearance of a two story dwelling. There were 6 filters in each - 3 on either side of an operating gallery on the second floor. Valve control was manual from the operating gallery, using extension rods for the valves in the lower section of the double filters. Chemicals were elevated to a storeroom in the second floor, using an automatic chain hoist.

As the plant was not operating and records had been destroyed, no data were available as to the chemical characteristics of the water supplies, the chemical treatment and results obtained.

Items of Special Interest

These plants were of interest because of: (1) the architectural layout to give the impression that the buildings were residential, (2) the different coagulants used for the different water supplies, (3) the chemical mixing, controlling and feeding equipment with automatic controls and acid resistant piping.

TARGET NO. A-14

Name: Nüremburg Water Works

Location: Nuremburg and suburbs

Date Visited: August 2, 1945

Person Interviewed: Ipelkofer, general director

Interviewed By: A. E. Gorman

INFORMATION OBTAINED

General

In 1940 Nuremburg had a population of 440,000. The average consumption then was 97,000 m^3 per day or approximately 58 U.S. gallons per capita. Director Ipelkofer estimated that as of August 1, 1945 the population was 275,000 exclusive of the American military occupational troops. Because of the damage to the system the consumption at the time of inspection was 110,000 m^3 per day. A large proportion of the central part of the city was destroyed by bombing and the water transmission and distribution system had been seriously damaged.

Sources of Supply

There are three principal sources of supply; (see Fig. A-14-a): (1) Mountain spring water collected in specially constructed collecting galleries at Ranna 30 miles northeast of the city, (2) artesian water from wells and springs at Ursprung and Kramersweine about 7 miles southeast of the city, and (3) a well field at Elenstegen built in 1903, in the Pignitz Valley in the northeast section of the city. The third, which was once the major source, is now used principally to supplement the other two when the demands on them are great, or merely as an emergency source of supply. All water is delivered to four reservoirs in a group on a hill at Schmausenbuch, from which it flows to most of the city by gravity. There are booster pumps for service in high areas of the city. The water normally obtained from these sources and that supplied in July 1945, is summarized in the following table:

Sources of Water Supply - Nuremburg

Source	Normal supply maximum m^3 day	Supply July 1946 m^3 day
Ranna	43,000	47,455
Ursprung and Kramerswein	21,000	27,200
Elenstegen	33,000	35,700
Total	97,000	110,355

At Ranna, a spring-fed area, formerly a swamp between two mountains, has been excavated and back-filled with stone and gravel to a depth of 8 meters. It supplies about 42,000 m^3 per day. The collecting area is covered with a concrete slab on which topsoil has been placed to permit plantings of grass, shrubs and small trees. Two collecting pipes deliver the water to a central concrete basin. On another slope of the mountain in the same area, a concrete lined tunnel 500 m. long and 3 m. in diameter, in the wall of which there are slots about 6 inches wide and 25 inches high, also intercepts underground water flow. About one-sixth of the total Ranna supply comes from this tunnel. The flow from both sources is measured in a collecting basin by elevation over vertical uptake pipes discharging into cast iron mains which deliver the water without treatment to the transmission main to the city. In addition to these supplies, there are two deep (40 and 80 m.) wells beyond Ranna with a capacity of 20,000 m^3 per day and an artesian spring at Buckenberg with a capacity of 2000 m^3 per day which can discharge into the transmission line from Ranna to the city. Supply from the Ranna sources is now limited by the carrying capacity of this line to about 50,000 m^3 per day.

The Ursprung artesian wells and Kramerswein deep wells have capacities of 18,000 and 12,000 m^3 per day, respectively. This water is discharged by a pipeline into the Schmausenbuch reservoirs. A recently installed booster pumping station below the reservoirs has increased the capacity of the supply line from these sources from 20,000 to 26,000 m^3 per day.

There are now 100 wells at the Elenstegen plant. They are 12-14 meters deep and have a capacity of 36,000 m^3 per day. The excavated section of the wells is 900 mm. in diameter. The central well pipe is 300 mm. in diameter. The packing around the pipes is coarse, medium and fine gravel in concentric rings from inside outward. The earlier screens were of copper with cast iron discharge pipes. The recent ones are constructed of ceramic material. Well spacing is 30 m.

Treatment

Only the well water at the Elenstegen works is treated. To remove manganese and iron from the water there are 16 vertical "Mangan" pressure filters with a total capacity of 36,000 m^3 per day. Twelve are double deck units 2.8 m. in diameter, and 2.0 m. high. The other 4 are 3.0 m. in diameter and 3.0 high. The double filters are washed by water using mechanical belt driven rakes. The newer triple filters are washed with air and water. The operator prefers the mechanical rakes and water washing system to the air and water method of washing. The filter bottom nozzles are of porcelain.

Transmission

A schematic diagram of the principal units in the Nuremburg transmission and distribution system is shown in Fig. A-14-a. There are 46 kilometers of cast iron pipe and 5 kilometers of reinforced concrete pipe in the transmission system. The main transmission line from Ranna is 30 kilometers in length and is constructed both of cast iron and reinforced concrete. It passes through 12 tunnels en route to the city.

Pumping

The two principal pumping stations are the old one at Elenstegen and the new booster station in the transmission line from the Ursung and Ranna sources to the Schmausenbuch reservoirs.

Electric power is used at both stations and all pumps are horizontal and centrifugal units. Their capacities are:

Station	Rated Pumping Capacity - m^3/day Pump No.1	Pump No.2	Pump No.3
Schmausenbuch Booster	33,000	33,000	66,000
Elenstegen	12,000 to 33,000		12,000 to 80,500

There are 3 booster pumping stations, one to the Hohe Bühl reservoir, a second to Zeppelenfeld, and a third to Ziegelstein.

Storage

The principal storage reservoirs are the 4 on the hill at Schausenbuch. They are of brick and concrete construction and covered by earth embankments. Entrance is by an

inspection gallery, well lighted and tile lined. The entrance doors, both internal and external, are locked and sealed. The capacity of the principal storage reservoirs is given in the following table:

Capacity of Principal Reservoirs - Nuremburg

Reservoir	Capacity m^3
Schmausenbuch No.1	50,000
" " 2	12,000
" " 3	8,000
Hohe Bühl	20,000

The Hohe Bühl reservoir is served from the others by a booster pump and it supplies the high pressure area in the southern section of the city.

Distribution

The distribution system consists of 677 kilometers of cast iron pipe distributed by sizes as follows:

Diameter of Pipe mm.	Length of Kilometers
500-1000	20
250-500	24
100-250	222
80-100	411
Total	677

There are 4700 hydrants in the system of which 3500 are of the above ground type. All consumers are metered, the total in service being 46,000. Pressure in the system varies from 30 to 60 psi.

Quality

Recent analysis of the water from the various sources of supply are summarized in the following table:

	Sources of Supply			
Item	Ranna	Ursprung	Kramerswein	Elenstegen
Total hardness (U.S.)	121	75	81	85
Ph	7.2	7.2	7.2	7.2
Iron-source ppm.	0	0	0	0.2
" treated "				0.02
Manganese-source ppm.				0.5
" treated "				0.0
Free CO_2	0	0	0	0.0

The bacterial analysis of a series of samples reviewed showed no gelatine counts at 22°C in excess of 5 per m/l, and no gas formers in lactose broth incubated 48 hours at 37°C.

War Damage

The Nuremburg water system suffered serious damage from bombing. When the American troops entered early in May, the only transmission main from the Ranna and Elenstegen sources was one 450 mm. cast iron pipe. All of the other 5 lines had been broken. Water was being obtained from 68 wells in the city, 15 of which were at bomb shelters. Earlier in the war one bomb crashed through the roof of the main storage reservoir at Schmausenbuch. The dirt coverage over this reservoir was 2 feet with a 12 inch reinforced concrete slab roof. The hole through the roof was about 20 mm. diameter. There were 1200 breaks in the distribution system, averaging 5 m. of damaged pipe per crater, or a total length of 6000 m. This is about .9 percent of the system.

Items of Interest

The Nuremburg water system is of special interest because of (1) the method and structures used in developing the Ranna spring supply, (2) the layout and design of the new booster pumping station at Schmausenbuch, (3) the large pressure filters for removal of iron and manganese at Elenstegen, and (4) the construction and protection of the water in the storage reservoirs. The system appeared to be well managed and maintained.

TARGET NO. A-15

Name: Munich Water Works

Location: Munich and foothills of Bavarian Alps

Date Visited: August 2, 1945

Person Interviewed: Herpich, director, Water Department

Interviewed By: Fischer, Gorman

INFORMATION OBTAINED

General

In 1940, Munich, the principal city of southern Germany, had a population of 850,000. It was estimated by director Herpich that the population as of August 1, 1945, was 500,000. At the time of inspection about 160,000 m^3 water per day were being supplied. The city was heavily damaged by bombing and other war actions.

Sources of Supply

The water is supplied from 3 underground gallery collecting sources known as Reisach, Gotzing and Muhlthal, in the foothills of the Bavarian Alps, 15 to 20 miles southeast of the city. In normal times the average water supply from all sources was 260,000 m^3 per day, with a minimum and maximum range of 200,000 and 425,000 m^3 per day. The average corresponds to 80 gallons per capita for a population of 850,000. The Reisach plant, 20 miles from Munich, has a deep central collecting well into which 4 galleries discharge and from which water flows to the city reservoirs by gravity through two outlet conduits. The collecting well structure is beautiful in appearance with its white tile lined walls, marble slab floors and staircases. The internal diameter of the structure is 5 m. and it is in 3 levels. The gates and valves to the gallery shafts are of corrosion resistant steel. The 4 collecting galleries are 1.35 m. in diameter and each of the two outlet conduits 1.15 m. in diameter.

There are 5 concrete collecting galleries at Gotzing. They are from 30 to 350 m. long, constructed under the mountain at points where they can most effectively intercept the ground water flow through the rock. Water from the Reisach and Gotzing

works come together at a central control and measuring station from which the mixed water discharges by gravity to the city. The drop in elevation from this point to the city is about 100 m.

The collecting galleries are of various types of construction depending on the ground penetrated. Some are of stone and others are of concrete with holes in the sides and top, or in both, and through which the water from the outside enters the gallery. As a rule the cross section is semi-elliptical, about 1.75 m. high and 1.0 meters wide. The delivery conduits, through which the water flows, are of concrete construction in two levels, with interconnecting stairways. The depth of flow depends on the volume of ground water collected and the rate of use in the city. Excess water passes out to the adjacent creeks through overflow pipes.

The construction is of good quality. All necessary control and measuring equipment, manual and recording, are installed in underground structures, well concealed by earth mounds. The doors, valves and apparatus are of non-corroding steel. Rooms housing control and recording equipment are lined in white or buff tile and the general impression as to maintenance and operation is that of high order. Inflow from the two systems and the rate of flow in the two conduits that lead to the city, is measured by flow through large cast iron recording Venturi meters.

The contributing watershed is sparsely settled. In excess of 8700 acres of it are owned by the city. The normal annual precipitation in the watershed is 1200 mm. or 47 inches. The water is cold (8.0°C or 46.4°F), all year round. As collected in the white tile lined basins the water presents a beautiful deep blue color.

At the Mühlthal works about 5 miles nearer Munich, there are 6 galleries under the mountain similar to those at Gotzing. Water from 3 of them was being spilled to the river because of damage to a main collecting line where a bridge over the Reichautobahn was demolished by German soldiers.

Transmission

The water, without treatment, flows by gravity from the outlet and control basins at the sources of supply through 3 transmission conduits to the 2 storage reservoirs which serve the system.

Source to Reservoir Transmission Lines - Munich

	Source	Reservoir	Material	Size meters	Length meters
I	Gotzing or	Diesenhofer	Brick-Re-Concrete	1.3x1.7	27.0
II	Muhlthäler	"	Reinforced "	1.0x1.6	26.0
III	Reisach	Kreuzpuliach	" "	1.7x1.8	20.0

The lines are cross-connected so that water may be transferred from one system to the other.

There are 5 principal transmission lines of cast iron and steel between the reservoirs and the city distribution system. They are of the following sizes and lengths:

Reservoir to Distribution System Transmission Lines - Munich

No. of lines	Material	Diameter in mm.	Length in m.
1	Cast iron	700	11.3
2	" "	700	12.8
3	" "	800	18.6
4	Steel	1000	15.3
5	"	2000	16.6

The average time of flow from the sources to the city is 10 hours.

Storage

There are 2 principal groups of storage reservoirs from which the city system is supplied by gravity. These are:

Storage Reservoirs-Munich

Reservoir	Units	Approximate Elevation above City System - m.	Total Capacity m^3
Diesenhofen	4	70	77,000
Krenpullach	4	100	100,000

The Diesenhofen reservoirs are of brick construction and the Krenpullach reservoir is of reinforced concrete with all surfaces painted white and with a white tiled inspection gallery across it above the water. It is a beautiful structure, lighted internally with numerous shaded lights, with the illumination directed on the water and producing a striking picture. The walls and floor of the entrance and control rooms are constructed of white tile and marble. All doors, valves, valve operating mechanisms and metal work are of non-corroding steel. Around-the-

end-baffles in each of the four units of the reservoir assure circulation of the water. Recording mechanisms indicate the water elevation in the various reservoir units. The rates of inflow and outflow are registered electrically on an illuminated panel.

The reservoir is located in a wooded area covered with earth on which grass, shrubbery and small trees have been planted to camouflage the works from aerial observation. Artificial camouflage was built over the entrances to the reservoir. An interesting feature was the construction of the caretaker's home on top of part of the entrance into the reservoir.

An underground valve and venturi chamber is located in the woods some distance from the reservoir. The ground level entrance door is counter-weighted so that it opens readily when the lock pin is withdrawn. As a safety measure, there is a large streamlined horizontal needle valve in the transmission mains to the city, which would close gradually and without vibration should a break occur in the line (see Fig. A-15-a and b). The large valves in the mains are vertical and fully enclosed. They can be operated by electric motor or by hand.

Another interesting feature is the provision made for the disposal of water when a section of the reservoir is drained. A large concrete reservoir with a capacity of 25,000 m^3 or the equivalent of any one of the four sections of the reservoir has been built in a ravine several hundred meters from the valve chamber. When draining is necessary, it is carried out quickly by discharging the water into this receiving reservoir. From the reservoir the water is discharged through a series of wells to the underground strata in the ravine. During the war the surface of this basin was camouflaged by floating islands on which trees and shrubs were planted in order to break up the sharp outline of the water's edge and to give the appearance from the air of a series of small ponds.

Distribution

There are 1700 kilometers of cast iron pipes in the distribution system. The sizes range from 80 to 1200 mm. in diameter. About 50 percent are in the 100-150 sizes. Joint materials used are hemp and lead. There are 11,800 hydrants, 11,000 valves and 51,000 meters in the system. Normal pressures during the day vary from 30-70 m. (41.5 to 100 psi); at night they are about 90 m., (128 psi).

Quality

Following is a partial chemical and physical analysis of the normal water from the principal sources:

Item	Sources: Gotzing and Reisach	Mühlthaler
Total solids ppm	226-306	240-280
Free NH_3 "	0	0
Free CO_2 "	0	0
Total hardness"	150	-
Chlorides "	4.0	4.0
pH	7.6	7.6
Temperature °C	8.0	8.0

Bacterial analyses are made regularly. The water is of excellent quality.

War Damage

As might be expected, the Munich water system suffered serious damage from bombing and other war actions, but not all at the same time. At one time or another during the war each of the 5 principal transmission mains into the city was damaged. There were several breaks in the 700 mm. pipe and two in the 1200 mm. main. During these emergency periods water was distributed to the stricken areas in tanks and by pumping directly into"over the ground"emergency water supply points.

When the highway bridge across the valley at Mülthlaer was demolished by the German soldiers late in April, the impact of the plate girder broke a principal concrete transmission line. As a result, the water collected from 3 of the 6 galleries at that source has been lost to the river. This amounts to about 51,000 m^3 per day.

There were 1,860 breaks in water mains and pipes. No damage was reported to the sources or the storage reservoirs.

Items of Interest

Although this water system has no purification units, it has much of interest to water works engineers concerned with the structural and operating aspects of impounding water supplies from underground sources. The collection, transmission and storage works and accessories are well planned, constructed, operated and maintained.

Items of special interest were: (1) the construction of the collecting galleries, (2) the extensive use of non-corrosive steel in the doors, gate valves and control mechanisms in the galleries and reservoirs, (3) the ventilation of the underground reservoirs, (4) the inspection gallery in the Krenpullach reservoir, (5) the lighting and internal decoration of this reservoir, (6) the recording equipment for flow and water elevation, (7) the use of counter weights for opening large, horizontal doors to underground chambers, (8) the underground disposal and conservation of drainage water from the reservoirs through the use of wells, and (9) the methods of camouflaging the reservoir entrances, underground valve basins and the receiving basin for reservoir drainage water.

TARGET NO. A-16

<u>Name</u>: Salzburg Water System

<u>Location</u>: Salzburg and vicinity

<u>Date Visited</u>: August 4, 5, 1945

<u>Person Interviewed</u>: Frey, director

<u>Interviewed By</u>: A.E.Gorman, Cahp. H. Moore

INFORMATION OBTAINED

General

Salzburg, Austria, lies in a valley between mountain ranges on both sides of the Salzach River. In 1940, it had a population of 70,000 and a water consumption of 15,000 m^3/day, or 57 U.S. gals. per capita per day. It was estimated by director Frey that as of August 1, 1945, the water system was serving 125,000 people with 19,000 m^3/day. The additional population is due to occupational military forces and the large number of displaced persons living in the city. All sources were not visited and much of the data concerning the sources and storage was obtained from notes of Capt. Moore, Sn.C.Officer with Military Government.

Sources of Supply

The water is obtained from mountain springs and two well fields in the nearby valleys. All sources are within 8 kilometers of the city. Their watersheds are not publicly owned and policed and are subject to some local contamination. The water receives no treatment. The sources of supply are summarized in the following table:

Source of Water Supplies

Source	Type	Supply m^3 Aug. 1, 1945
South		
Kuhlback	Mt. Spring	864
Furstenbrunner	" "	6,900
Glanegg	Sh. Wells	3,450
Moos	Mt. Spring	345
East		
Aigern	Sh. Well	690
"	Mt. Spring	350
Gaisberg	" "	180
Kendle	" "	350
Gersberg	" "	690
Gnigberberg	" "	530
North		
Tiefenbach	Mt. Spring	1,600
Total		15,949

By agreement with private interests the supply from Furstenbrunner had been limited to 80 liters/second (1.83 M.G.D.), although the transmission line had much greater carrying capacity. To assist in meeting the acute water supply needs the Military Government had ordered the supply from this source increased.

An interesting feature of the Glanegg well plant was that the head of the water flowing through the transmission mains from the Furstenbrunner reservoir was used through a hydraulic turbine to drive the pump which pumped water from the well field.

Transmission

The transmission lines are relatively small. In the south section they are of cast iron 275 and 375 mm. diameter. One line of steel is 200 mm. diameter. There are six lines in the east section varying in diameter from 125 to 80 mm. All are cast iron but one which is of cement asbestos - 100 mm. diameter.

Storage

The covered reservoirs are located near the spring and well sources and also on Mt. Monchsberg in the heart of town. They are fed by gravity and the flow from them to the city is by gravity. They have a total capacity of 6,410 m^3 (1.69 MG). These reservoirs are:

Location	Reservoir	Capacity m^3
Monchsberg Mt.	Old (1907 unit	1,000
	New (1929 "	1,500
	Utility " (bombed and being repaired)	1,000
	Elevated tower	50
Kapuzinberg Mt.	Geisberg	700
	Ginglerberg	1,000
	Gaisberg	40
Others	Nussdorf-NE	300
	Gingler-E	300
	Porsch-NE	45
	Glasenbach-E	45
	Maxglan-W	400
Total		6,380

Distribution

There are 224 kilometers of pipe in the entire system including the transmission line. Their diameters range from 375 to 80 mm. About 60 percent are in the 100-125 mm. sizes. There are 1100 hydrants and 6000 meters in the system. All services are metered.

War Damage

As a result of bombing there were 800 breaks in the distribution and transmission system. Only the so-called utility reservoir was damaged. It was still out of service at the time of our visit.

Items of Special Interest

This water system while of general interest because of the many gravity sources had no special target value.

TARGET NO. A-17

Name: Ulm Water Works System

Location: Ulm

Date Visited: August 8, 1945

Persons Interviewed: Klett, chief engineer; Weger, master mechanic

Interviewed By: Fischer, Gorman, Sheridan

INFORMATION OBTAINED

General

Ulm had a population of 40,000 in 1939. Because of military occupancy and the location of a camp for displaced persons in the city, the water works officials estimated that the system is now serving about 70,000 people. War damage was intensive in the central business section of the city. There has been considerable increase in industrial use of water in the city which has resulted in increase in demand for water supply. The average daily use of water in 1939, was 10,000 m^3, equivalent to 65.5 U.S. gallons per capita. The amount of water supplied the system in July 1945, average 25,000 m^3 per day or 93 U.S. gallons per capita.

Sources of Supply

The water is obtained from two sources: (1) a well field 2.5 kilometers southwest of the city on low land between the Danube and Iller Rivers, supplying about 23,000 m^3 per day, and (2) an artesian spring about 14 kilometers west of the city which supplies about 6000 m^3 per day.

The well field has 5 wells, 150-200 m. deep, operated under a vacuum system. They are spaced from 450 to 600 m. apart. The outer well chamber is 1000 mm. in diameter; the delivery pipe and screens are 600 mm. diameter. The screens are made of slotted cast iron pipe.

Pumping

The well water is collected in a central underground basin at the nearby hydro-electric power plant and pumped to the Kuhburg reservoir on a hill about a mile away. There are

two old motor driven centrifugal pumps, each of 11,750 m^3 per day capacity. A 200 HP steam engine with belt drive is held in reserve to operate the pumps if necessary. Pressure at the pumps is 7.75 atmospheres or 114 psi.

Transmission and Distribution

There are two 500 mm. diameter cast iron transmission mains from the pumping station to the reservoir and thence to the city. The cast iron transmission main from the spring source to the city is 350 mm. diameter. As a result of war damage there were 250 breaks in the distribution system, 150 of which had been repaired. There was no damage to supply and storage facilities.

Storage

There are 3 concrete, covered storage reservoirs:

Reservoir	Section	Capacity m^3
Kuhburg	W	11,900
Michaelsberg	NE	6,500
Wilhelmsberg	N	1,600
Total		20,000

The Michaelsburg reservoir is filled by gravity from the Kuhburg reservoir, and water to Wilhelmsberg is repumped from Michaelsberg. The service at Wilhelmsberg was for an army artillery school. Pressure in the city varies by service areas from 2.5 atmosphers (37 psi) in the east side to 5.5 atmospheres (81 psi) on the west side.

Quality

Following are the results of chemical analysis of the water from the well sources as collected April 21, 1944:

Analysis of Water at Ulm

Item		
Ph	7.3	
Total hardness (U.S.)	123.0	ppm
Carbonate "	106.0	"
Noncarbonate"	17.0	"
Iron	0	"
$CaCO_3$	93.0	"
$Mg\ CO_3$	21.4	"
Chlorides	9.0	"
SO_3	15.1	"

Items of Special Interest

The facilities at the water works offered nothing of special target value.

TARGET NO. 18

<u>Name</u>: Landkreis Aachen Water Works

<u>Location</u>: Headquarters, Brand

<u>Date Visited</u>: August 30, 1945

<u>Persons Interviewed</u>: Merkelbach, director; Schotz, Consult. Engr.

<u>Interviewed By</u>: A.E. Gorman, Maj. M.W. Tatlock

INFORMATION OBTAINED

General

The water in the suburban area of Aachen is supplied by a private company known as Wasserwerke Landkreis Aachen. This company supplies a population of about 240,000 people in an area 2000 sq. kilometers south, east and north of Aachen and including villages in Holland. Normally, about 60 percent of the supply is to industries in the area, especially coal mines. At the present time, the distribution of use is about one-half to industry and one-half for domestic use in the numerous small villages and cities.

Some water is supplied the city of Aachen varying from one-sixth to one-third of the supply and depending on requirements. The distribution system of Aachen is interconnected with the suburban system at numerous points.

Source of Supply

The water for the system is obtained from two major reservoirs:

Name of reservoir	Year put in Operation	Capacity million m^3	Water Shed Area sq. kilometers
Dreilagerbachtalsperre	1912	4.28	22.93
Kalltalsperre	1934	2.10	29.5

The former source is about 16 kilometers southeast of Aachen at elevation 392. The latter at elevation 420, is about 6.3 kilometers southeast of the former and is connected to it by a concrete gravity tunnel through the mountains, 2.2 m. high and 1.5 m. wide.

The supply of water from the source is:

	Water Supplied - Million Gals. per Day		
	For Domestic Use	For Industrial Use	Total
Normal - 1940	4.10	5.75	9.85
Present 1945	3.58	3.58	7.16

Treatment

The reservoir water is treated at Dreilangerbach in 8 steel open gravity rapid sand filters. Each is 5.0 m in diameter and the total area of the filters is 206 m^2. Under normal operation the average rate of filtration is 3.2 U.S. gals. per square foot per minute. The filter sand is from 0.6 to 1.0 mm. in diameter and washing is hydraulic, using mechanical rakes. No coagulents are used. The water is treated before filtration by .25 ppm of chlorine and after filtration at a similar rate.

Transmission

There are about 600 kilometers of cast iron pipes in the transmission system to the various industries and cities. The latter maintain their own water distribution systems and service facilities to customers. The two principal mains to the system from the filter plant are 800 and 475 mm. in diameter. About one-half of the transmission mains are cast iron. The remainder are steel and reinforced concrete.

Storage

There are three elevated steel storage tanks and one reinforced concrete underground reservoir in the system. The underground reservoir, which is the largest, is the principal distributing reservoir in the system. These reservoirs and their capacities are:

Name of Reservoir	Type	Capacity m^3
Bardenberg	Elevated	500
Alsdorf	"	1000
Palenberg	"	500
Eilendorf	Underground	6600
	Total	8600

Quality

The following is a typical analysis of the water supplied consumers:

Item	Amount
Ph	6.8
Free CO_2 ppm	5.5 to 5.7
Total hardness ppm	17.0
Iron	slight
Manganese	"

Items of Special Interest

This system is interesting as an example of a large water system serving numerous communities in an industrial area, but its facilities and method of operation are considered to have no special target value.

TARGET NO. A-19

Name: Stuttgart Gallenklenge Water Treatment Plant

Location: Stuttgart

Date Visited: July 26, 1945

Person Interviewed: Robert Scholar, director

Interviewed By: Lt.Col.Gilbert, Lt.Pfreimer, Dr.Sheridan

INFORMATION OBTAINED

General

In 1940, Stuttgart had a population of 500,000, with an estimated water consumption of 30,000,000 gallons per day (60 U.S. gal./cap.).

Source of Supply

The present water supply system is the result of three-quarters of a century of gradual development whifih has brought water to the city from three sources of supply. The principal source is a system of wells located in the Alps about 100 kilometers from the city. This water is pumped to a high elevation reservoir from which it flows by gravity to distribution reservoirs in or near the city. Approximately two-thirds of the total supply comes from this source and no treatment is used. A second source of supply is from lakes located 55 kilometers from the city. This water requires treatment because of the constant existence of biologic growths and a chemical characteristic causing incrustations within the pipe. The third source of supply is from shallow wells (approximately 5 m. deep), located near the Neckar River. In case of low supply, water may be taken directly from the river. All of this water is very hard, ranging from 200 to over 500 ppm, depending upon the source, with an average hardness in excess of 300 ppm. Water from the lakes, the shallow wells or the river is treated in three different plants.

An old plant built in 1873, is still in operation, but is very ineffective. It consists of sand and charcoal filters with provision for aeration to eliminate odors resulting from biologic growths.

A second plant (Berg) treats the water from the shallow wells or from the Neckar River. At this plant the water is super-chlorinated, followed both by rapid and slow sand filtration (see Fig. A-19-a). Alum was formerly used as a coagulent, but its use has been discontinued because of difficulty in obtaining it under wartime conditions.

At the target plant at Gallenklenge - capacity 40,000 m^3/day - the lake supply is treated in the following manner:

(a) Super-chlorination with 5 to 9 ppm of chlorine.
(b) Alum coagulation with the addition of powdered activated carbon for odor removal.
(c) Two hours settling in concrete basins.
(d) Second addition of carbon if required before filtration.
(e) Ph adjustment from 7.1 to 7.3 before filtration.
(f) Rapid filtration - 5 m^3 per m^2 per hr. (2 gal./sq.ft/min.).
(g) Rechlorination.
(h) Dechlorination with granular activated carbon. A portion of the flow is bypassed to obtain 1.0 ppm chlorine residual in the system.

Items of Special Interest

The interesting feature of this plant is its treatment of a surface supply for taste and odor by super-chlorination, reduction of excess chlorine by powdered activated carbon followed by dechlorination, using granulated activated carbon. These treatment processes proved very satisfactory.

There are four filters. Construction is such that the filter room is separated from the rest of the plant by glass windows set in rubber. This was done to protect the operator from any chlorine fumes which might be given off in the super-chlorination of pretreated water. Experience proved this precaution to be unnecessary. The sizes of filter media are as follows:

Sand	.5 to 1.0 m.
Fine gravel	4-6 mm - .2 m.
Gravel	10-20 " - .1 "
Coarse gravel	.1 m.

The underdrain system consists of porcelain strainers of the BAMAG type spaced 30-40 cm on centers. The use of porcelain eliminates the corrosion encountered when copper was used. A float on the water surface of the filter automatically closes the influent pipe valve during backwashing. Filters are backwashed at a rate of 1/2 m./min. velocity or 1.64 ft./min. It was reported that the high chlorine residual carried in the super-chlorinated water does not increase the filter runs.

The settling tanks are cleaned only two or three times a year. This is done by emptying the tanks and removing the accumulated solids manually.

TARGET NO. A-20

Name: Bamag-Meguin Aktiemgesellschaft "BAMAG"

Location: Giessen

Date Visited: July 20, 21,30, 1945

Persons Interviewed: Bauer, engineer, Wedt, water specialist

Interviewed By: Lt.Col. J.J.Gilbert, Lt. Pfreimer

INFORMATION OBTAINED

General

This company, whose headquarters and factory were in Berlin, manufactures equipment and supplies for heavy industries and has a special division which designs, manufactures and installs equipment for water purification, sewage and industrial waste treatment and disposal, and related fields in sanitation. It has installed equipment in all sections of Germany, in many countries in Europe, and also overseas. The Berlin plant was destroyed and its headquarters are now moved to Giessen. The plant facilities there have been temporarily diverted by the military authorities to production of other equipment so production of water supply equipment and supplies has been suspended.

Engineer Wendt was interviewed with the objective of obtaining information relative to equipment made for water purification and data relative to design and operating practice in this field in Germany.

Pressure Filters vs. Settling Basins

Pressure filters without settling are recommended when relatively small amounts of chemicals are needed for coagulation. Under other conditions settling basins and/or rapid sand gravity filters are desired, especially with waters of turbidity in excess of 100 ppm. and when the "mucus" type of algae are present in the water. Thread-like algae are not troublesome in pressure filters, but the mucus type are. Settling periods of 2-4 hours are normally recommended.

Rates of Filtration

When rapid sand gravity filters are used for removal of ordinary suspended matter in settled water, the range of filtration rates recommended is from 1.67 to 2.5 gals. per sq. foot per minute (9 gsfm). When filtration is to remove flocculated iron and manganese, these rates may be increased to the range of 2.5-3.75 gsfm.

In pressure filters with a single chamber used for ordinary filtration, rates can vary from 2.5 to 3.75 gsfm; for iron and manganese removal 4.0-5.0 gsfm. In double chamber filters these rates can be doubled.

Filter Media

In ordinary pressure filters silica sand is used. When conditions indicate the need of a roughing filter, crushed coke is sometimes placed above sand in pressure filters. Anthracite coal is not used because it is expensive. For iron removal a volcanic lava is used. It is preferred to coke because it is harder, has more cells and retains air. The lava must be renewed every 5 to 10 years. With silica sand no renewal is required. For manganese removal the best media is a natural dolomite mined in Russia which consists of magnesium oxide, and magnesium and calcium carbonate. Since the war it has been unobtainable and sand has been used. The depth of sand is 1.3 m. below which there is graded gravel in increasing sizes to the full depth of the filter. For iron removal, only the total depth of these filter media may be 1.5 m. The sand size varies from 0.8 to 1.5 mm. diameter.

Flocculation

For quick mixing the hydraulic jump is preferred. With mechanical mixing the time required is usually 10 to 20 minutes. Around-the-end mixing basins are obsolete.

Air and Water vs. High Rate Water for Washing Filters

It is cheaper to produce air than clean water, and the use of air saves water in filter washing. Use of air helps prevent odors from developing in filters when the water to be filtered contains algae. Air has the objection of binding filters unless the operator is careful when washing them. Competition has forced BAMAG to provide air and water wash. Its engineers admit advantages of high rate water washing of filters. Air pressure during washing is usually 0.6 atmospheres (9.4 psi); water pressure is 0.4 atmospheres (6.3 psi). The

rate of back wash using water **alone** is 0.4 to 0.5 m^3 per m^2 per minute (9.8-11.8 gsfm); with air it is 0.6 m^3 per minute (14.7 gsfm) and in combination it is 19.6 gsfm.

When filters are washed air is admitted first for a period of from 0.5 to 1.0 minutes. This is followed by combined washing with air and water for a period of 10 to 12 minutes. The air is then turned off and the filter is back washed with water for .5 minutes to eliminate the air.

The use of wash water in German rapid sand gravity filters varies from 2 to 4 percent of the water filtered.

Mechanical rakes in sand filters are used and are effective. Generally, they are too expensive to maintain and operate in comparison with air and water washing.

Filter Underdrains Nozzles

The BAMAG nozzles are of two types: (1) those which admit water only (see Fig. A-20-a), and (2) those which admit both air and water (see Fig. A-20-b). They are patented nozzles and can be used in all types of filters. Porcelain nozzles have given superior results to those made of copper in which a galvanic action takes place which causes corrosion. The breakage of porcelain nozzles is high and work is being done on the substitution of a plastic material suitable for this use. The nozzles are made in two sizes measured by the internal diameter of the inlet pipe: 3/8" and 1/2". The spacing of the nozzle depends on the type of water to be filtered and back washing conditions. The nozzles are sealed in place by rubber gaskets.

Washwater Troughs

Concrete has been used in recent years because of the shortage of steel and has proved satisfactory.

Chlorination

Water from rivers or wells and infiltration galleries near rivers are usually chlorinated. Pre-chlorination of water affects the biological growths in filters and has an unfavorable effect on the efficiency of chlorination. It often causes objectionable tastes in the water. Post chlorination is preferred. Chloramine treatment is practiced in Germany more in swimming pool water purification than in the treatment of

drinking water. A stable calcium hypo-chlorite compound known as Caporit and containing 60 percent available chlorine is used widely in Germany.

Illustrations of various types of water purification equipment used by this company are shown in Figs. A-20-a to A-20-p.

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ILLUSTRATIONS AND DIAGRAMS

SECTION A

REPORT ON WATER SUPPLIES IN GERMANY

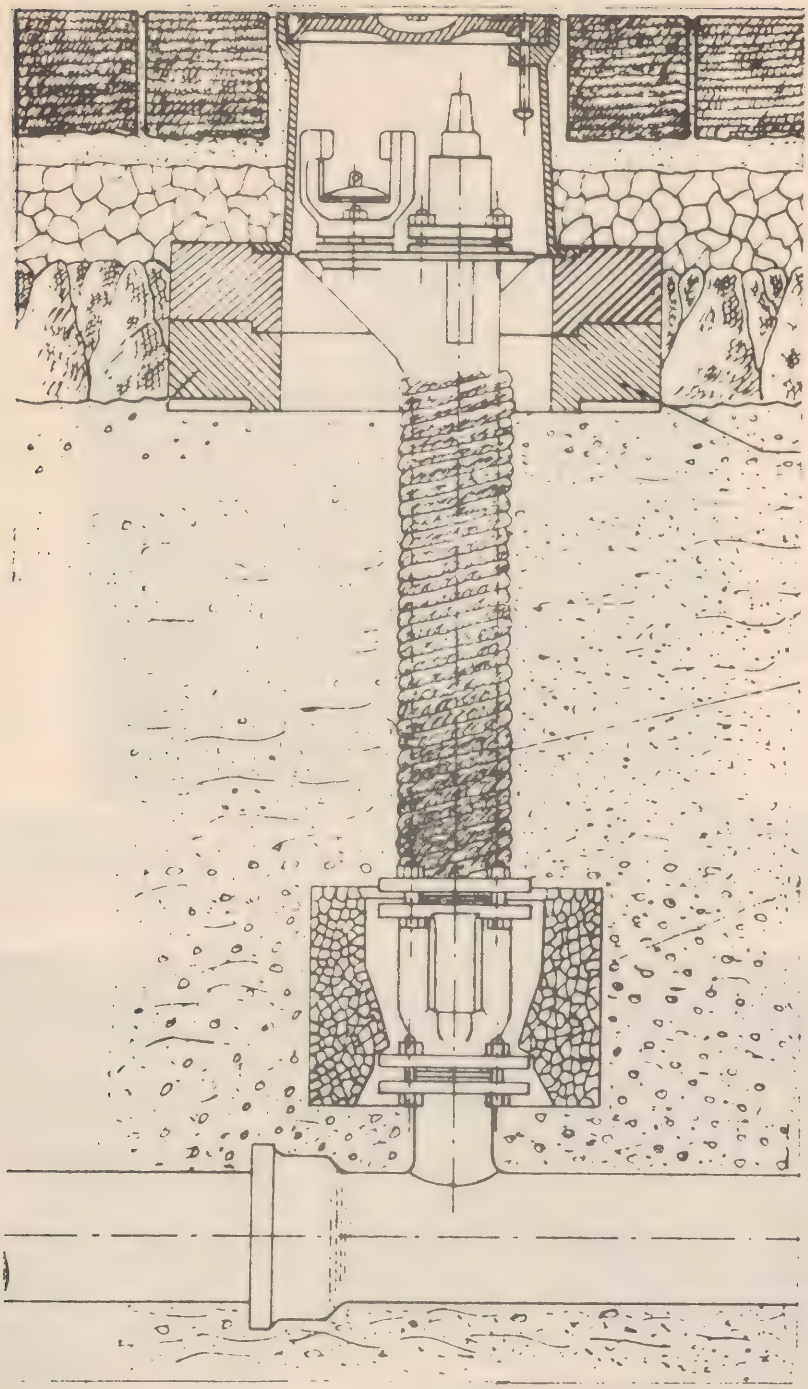

Fig. A-1-a, Method of installing and underground hydrants and protecting them against freezing - Leipzig.

Fig. A-1-b, elevated storage tank at Probstheide Station, Leipzig. Roof covering was destroyed by bombing in vicinity.

Fig. A-1-c, repairing two of three transmission lines from Naunhof Station to Probstheide Station damaged by bombs. Note use of temporary wooden flume.

Fig. A-1-d, repairing damage to Naunhof-Probstheide brick transmission line by heavy bombing of April 6, 1945.

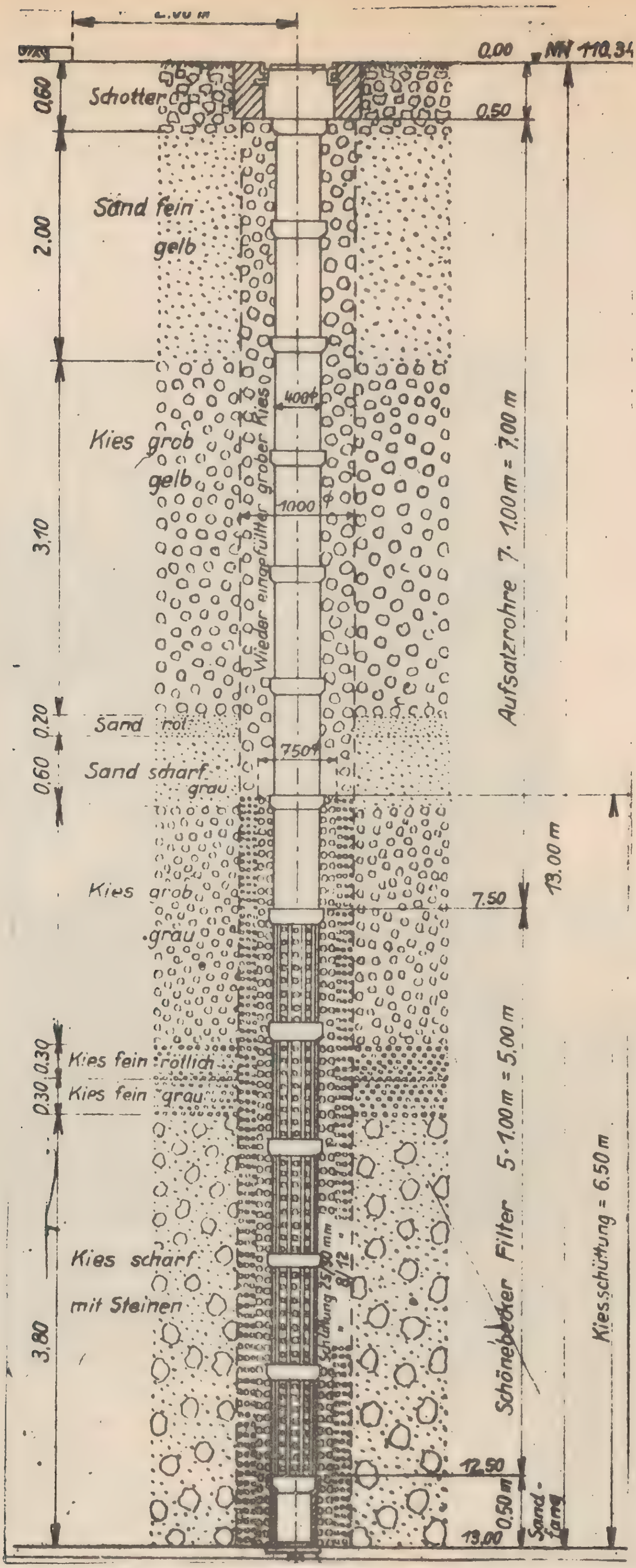

Fig. A-1-e, typical well constructed at various points in Leipzig to supplement public water supply during war emergencies.

Fig. A-1-f, emergency hand pump from well under street in Leipzig. Water used by residents when public supply cut off.

Fig. A-1-g, gasoline motor driven pumps used for emergency service during the war - Leipzig.

Fig. A-1-h, emergency water supply from underground hydrant to overground system using fire hose.

Fig. A-1-i, fracture to main concrete sewer by aerial bombing - Leipzig.

Fig. A-1-j, bomb damage to trunk sewer - Leipzig.

Fig. A-1-k, sewage flowing in damaged sewer in Leipzig.

Fig. A-3-a, revolving screens for river water at
Buna Werke-Schkopau

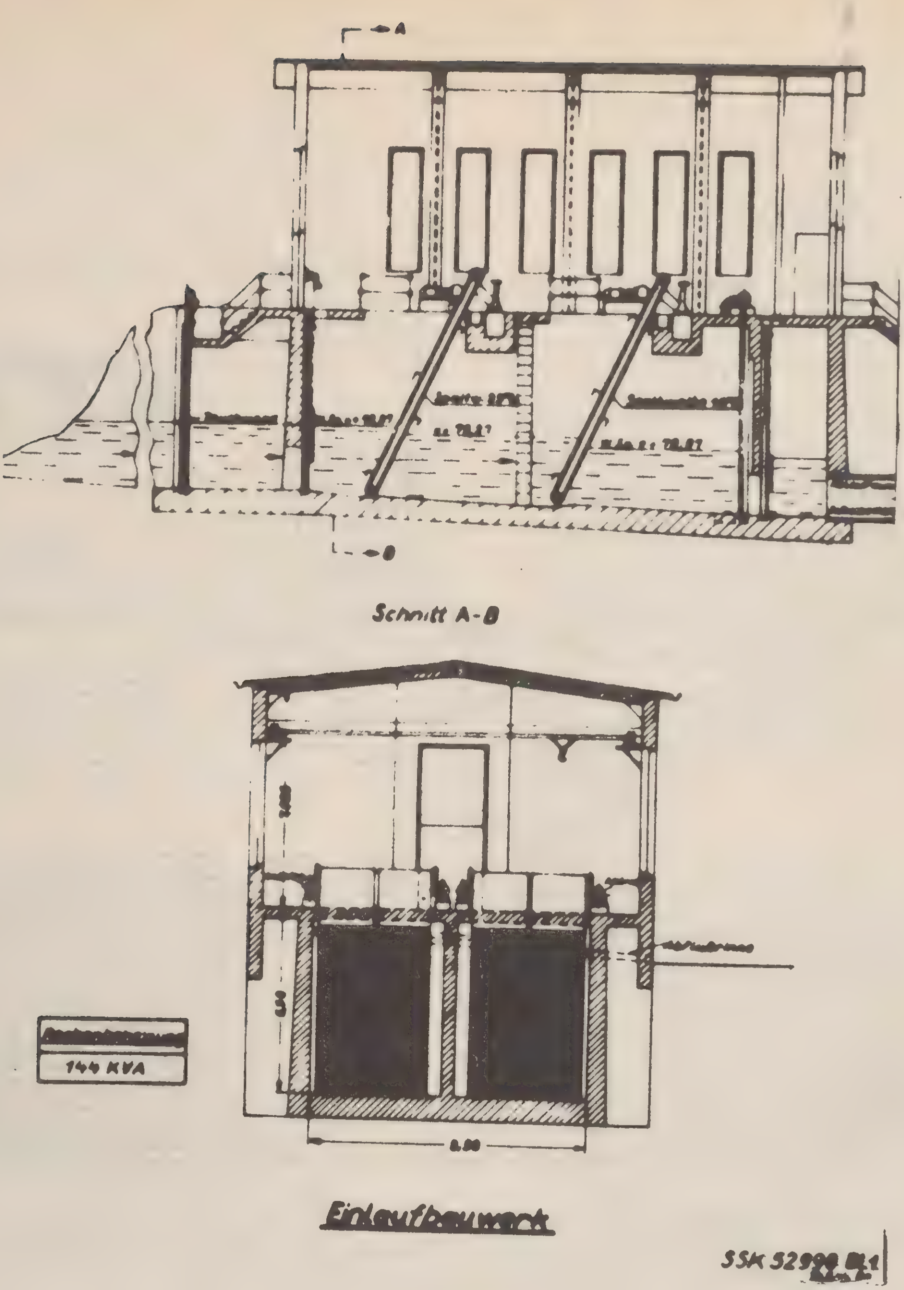

Fig. A-3-b, section and elevation of revolving screens at Buna Werke-Schkopau

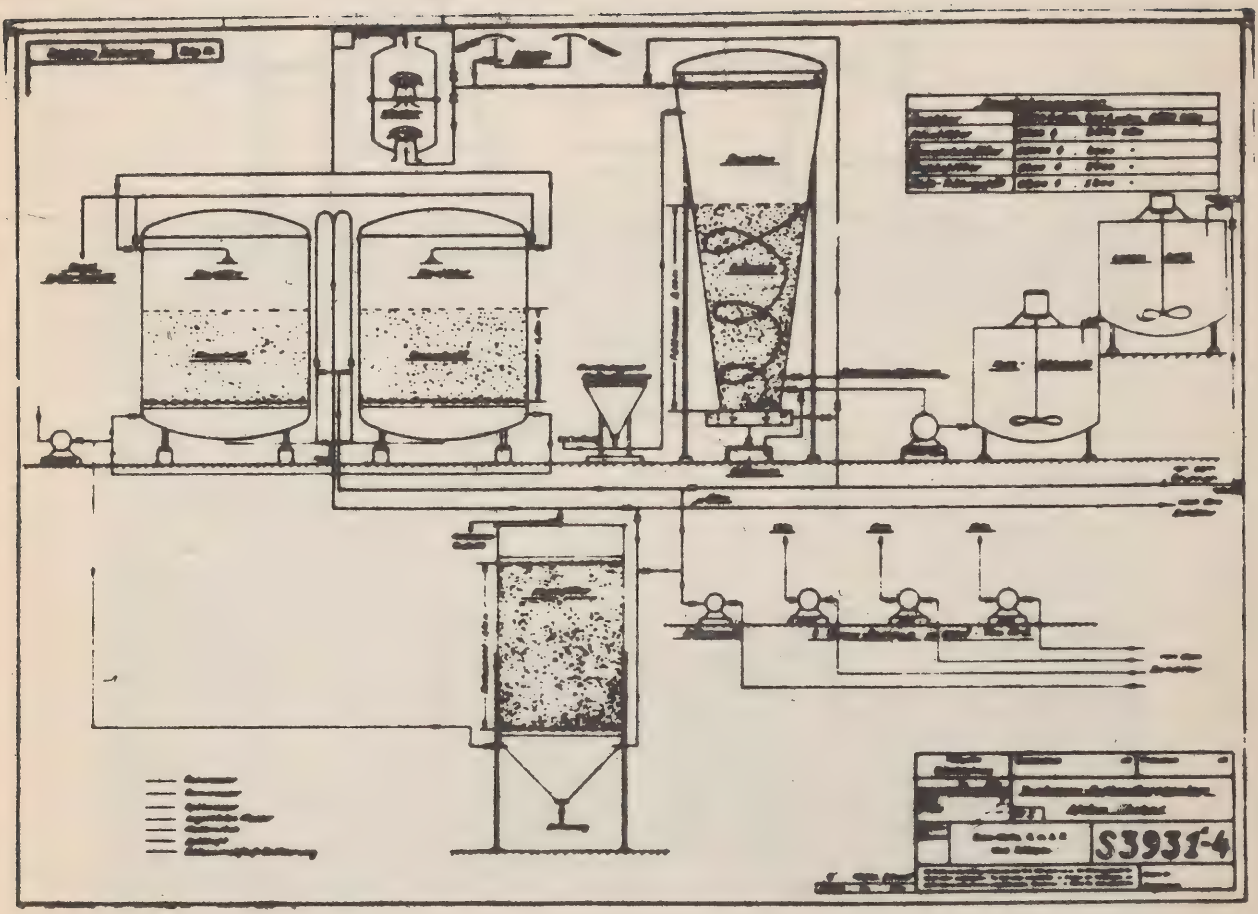

Fig. A-3-c, treatment of drinking water at Buna Werke-Schkopau for removal of carbon dioxide, iron and manganese and final filtration through activated carbon.

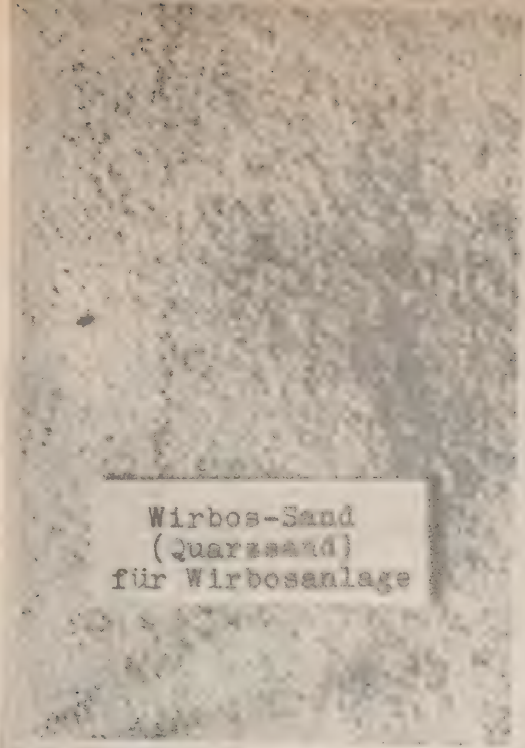

Fig. A-3-1, Wirbos-sand (Quarz-sand) for Wirbos installations.

Fig. A-3-e, marble-split for Wirbos installations.

Fig. A-3-f, final condition of the reactive mass of the Wirbos-sand (Quarz-sand).

Fig. A-3-g, final condition of the reactive mass of the marble split.

Vorklärbecken

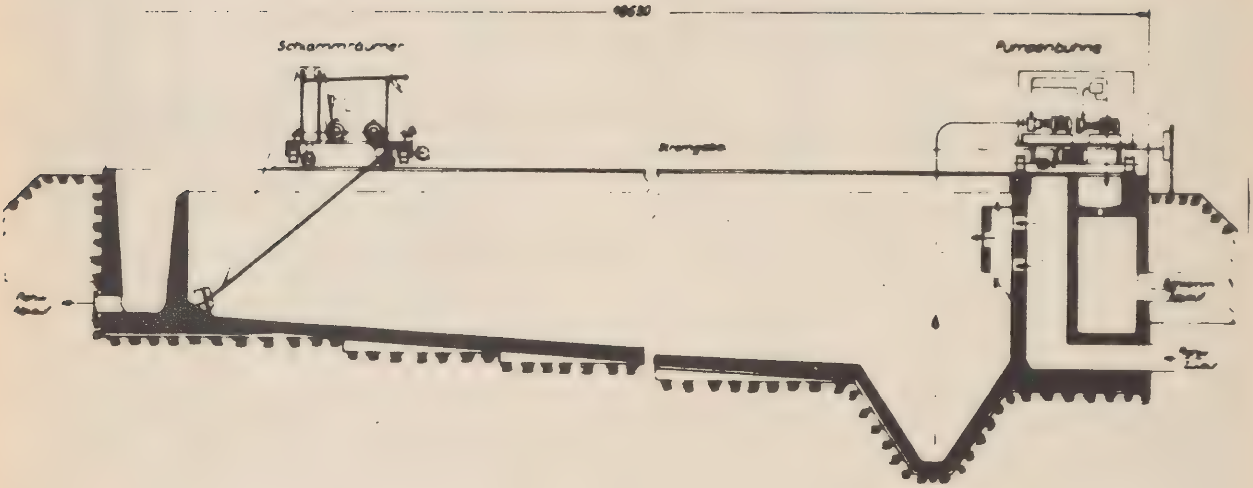

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Fig. A-3-h, section through settling basins at Buna Werke-Schkopau.

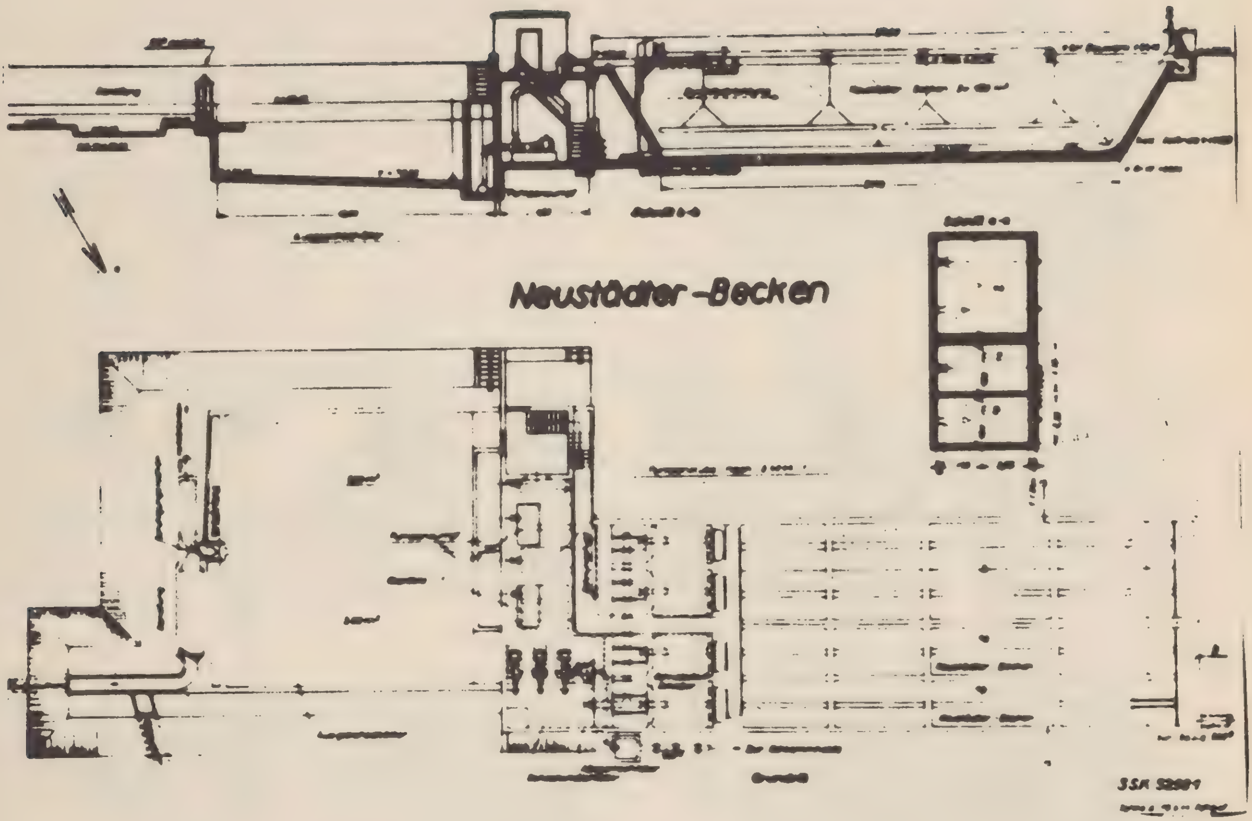


Fig. A-3-i, section and plan of Neustadter-Becken sludge concentrating tank used at Buna Werke-Schkopau

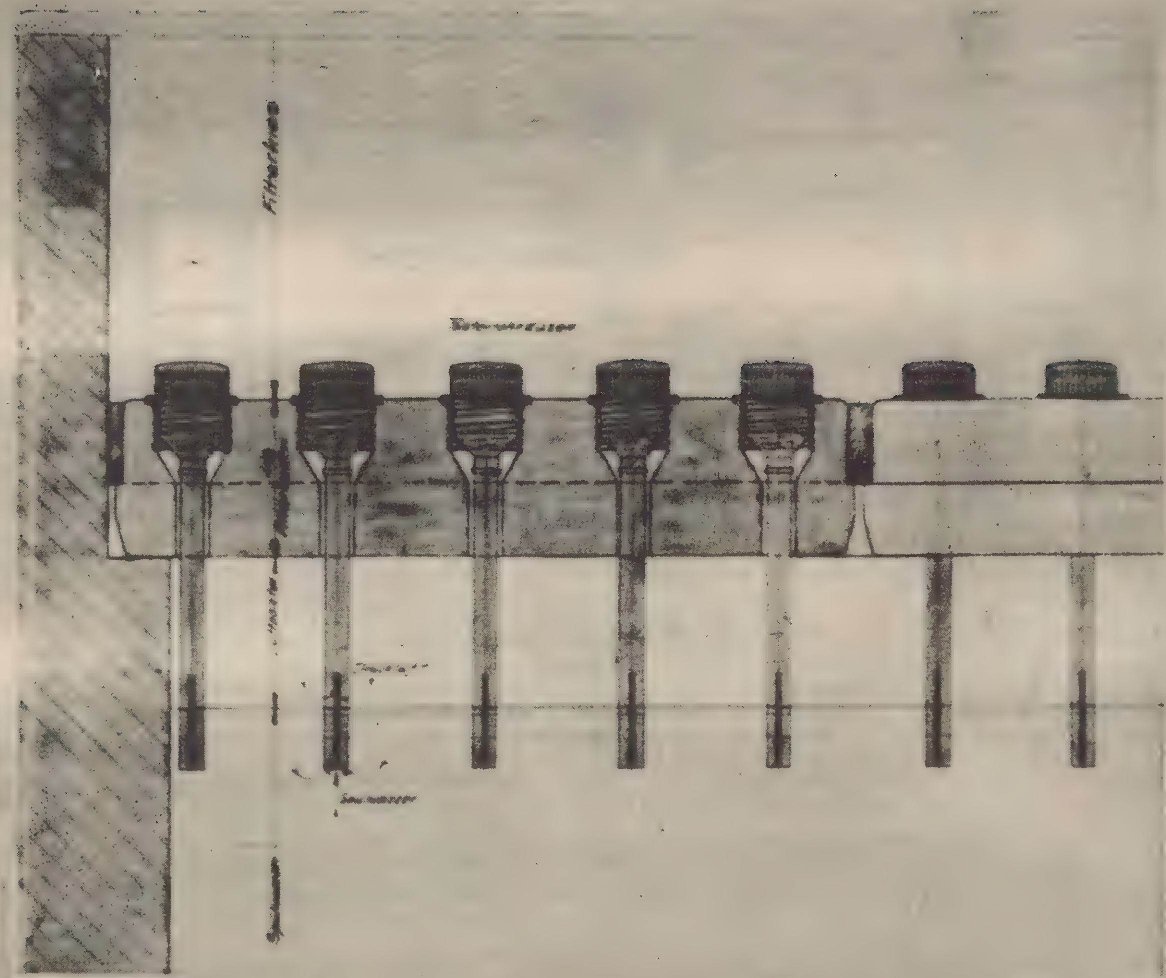


Fig. A-3-j, slab filter bottom and nozzles in typical WOBQG Rapid Sand Filter

Fig. A-3-k, filter gallery showing control tables, loss of head guages and filters. Buna Werke-Schkopau

Fig. A-3-l, pipe gallery WOEOG Rapid Sand Filter Plant Buna Werke-Schkopau

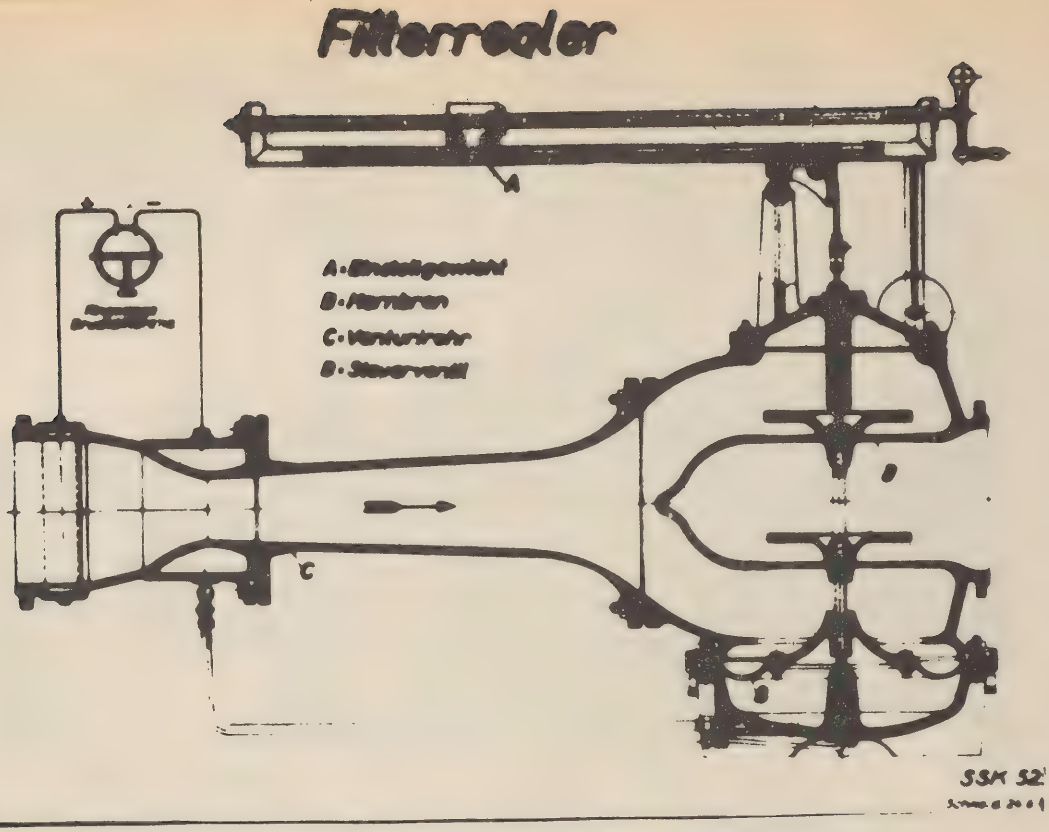


Fig. A-3-m, rate controller for WOBAG Filters -
Buna Werke-Schkopau

Fig. A-3-n, low lift pumps for plant water system
Buna Werke-Schkopau

Fig. A-3-o, high pressure pumps for plant water supply, Buna Werke-Schkopau

Fig. A-3-p, control station (in gallery) for pumping units and auxiliaries at Buna Werke-Schkopau

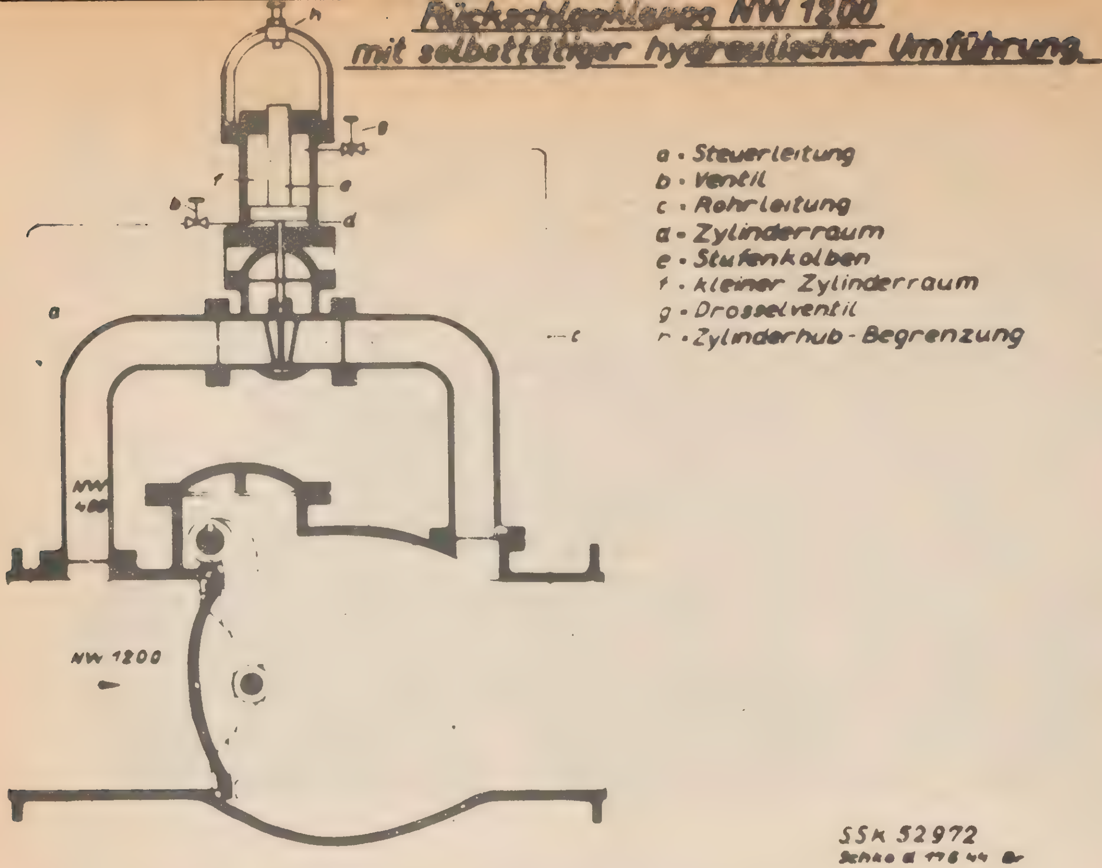


Fig. A-3-q, section through check valve on discharge of high pressure pumps at Buna Werke-Schkopau.

Fig. A-3-r, installation of large steel and cast iron water main - Buna Werke-Schkopau. Note special saddle and thrust foundations.

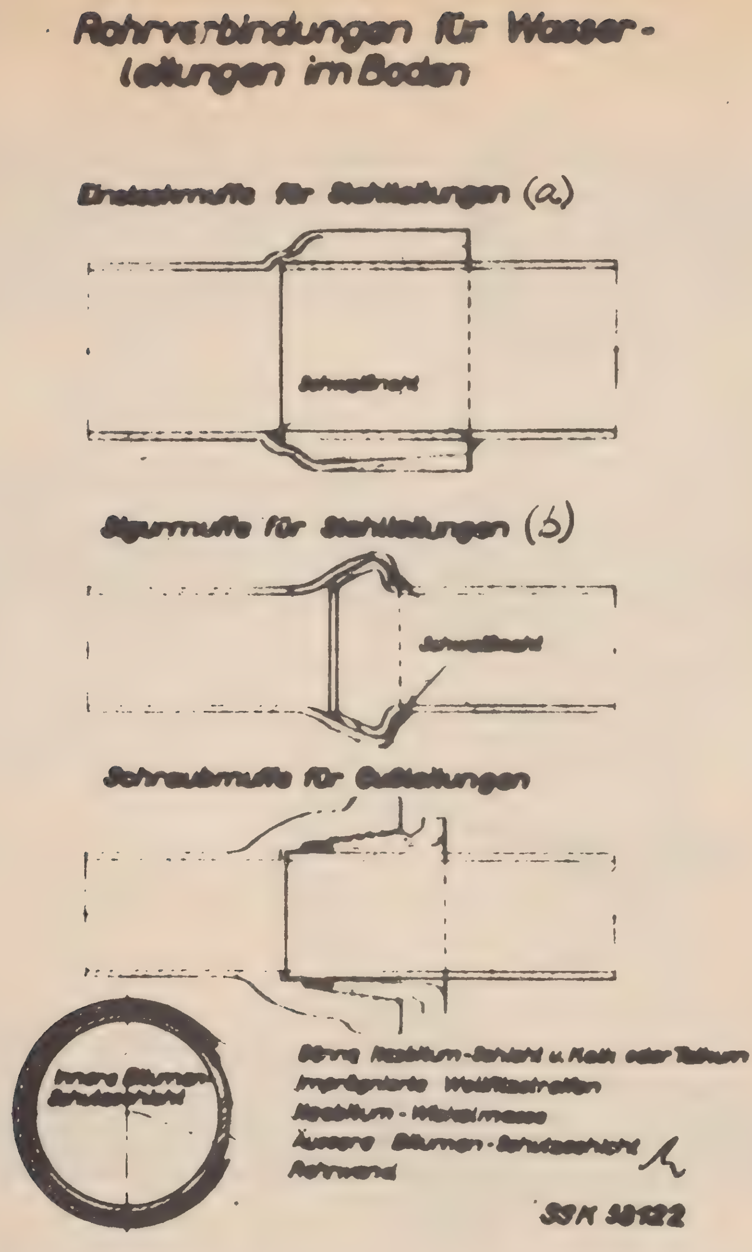


Fig. A.3-s, special joints for steel
and cast iron pipe - Buna Werke-Schkopau.

Fig. A-3-t, special joint for cast iron pipe using threaded nipple, rubber gasket and special wrench.

Fig. A-3-u, battery powered valve opening madrine used at Buna Werke-Schkopau.

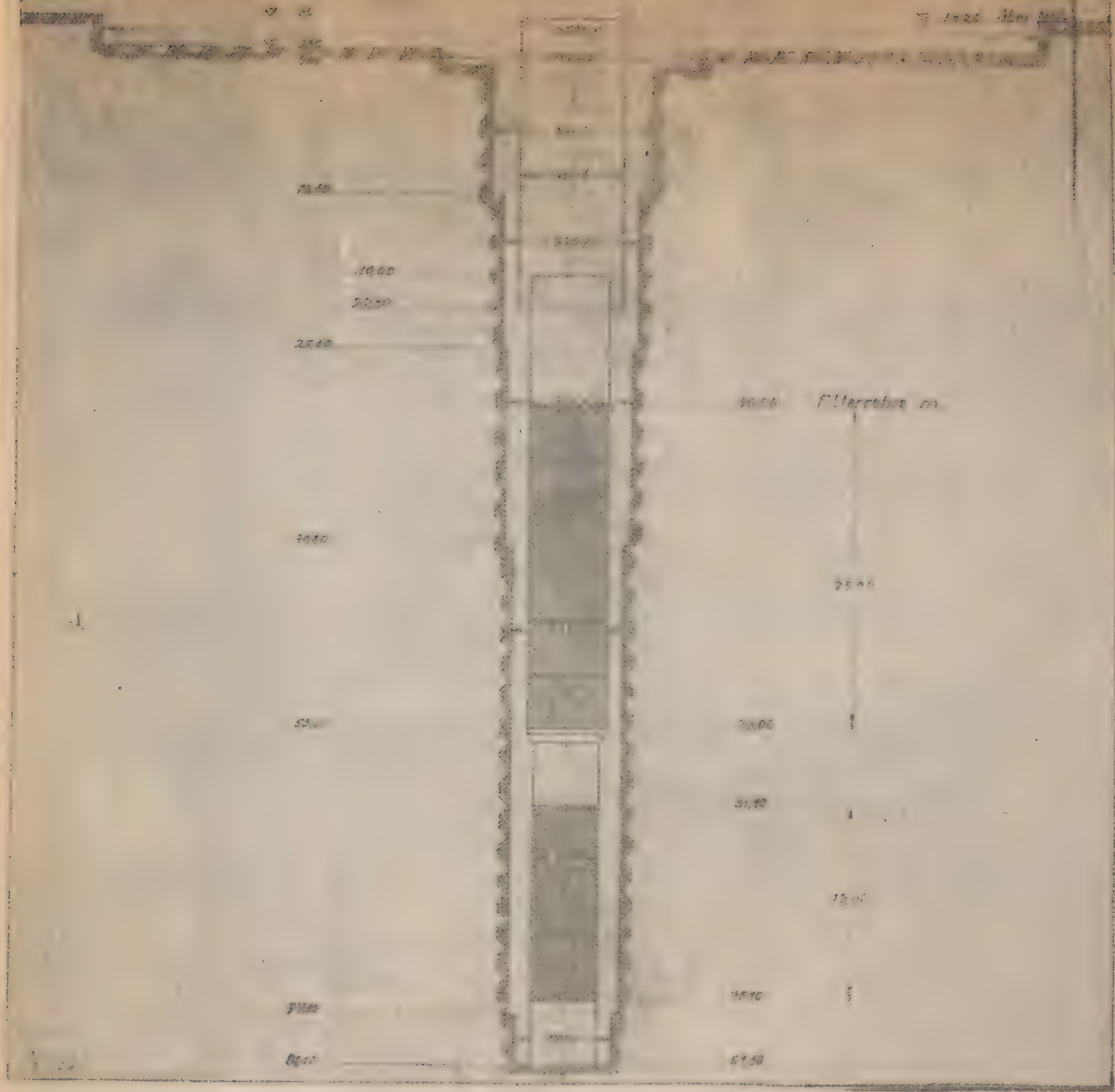


Fig. A-4-a, section of deep well at Eichwald Kassel Water Works.

Fig. A-4-b, ceramic type well screens of type used at Kassel.

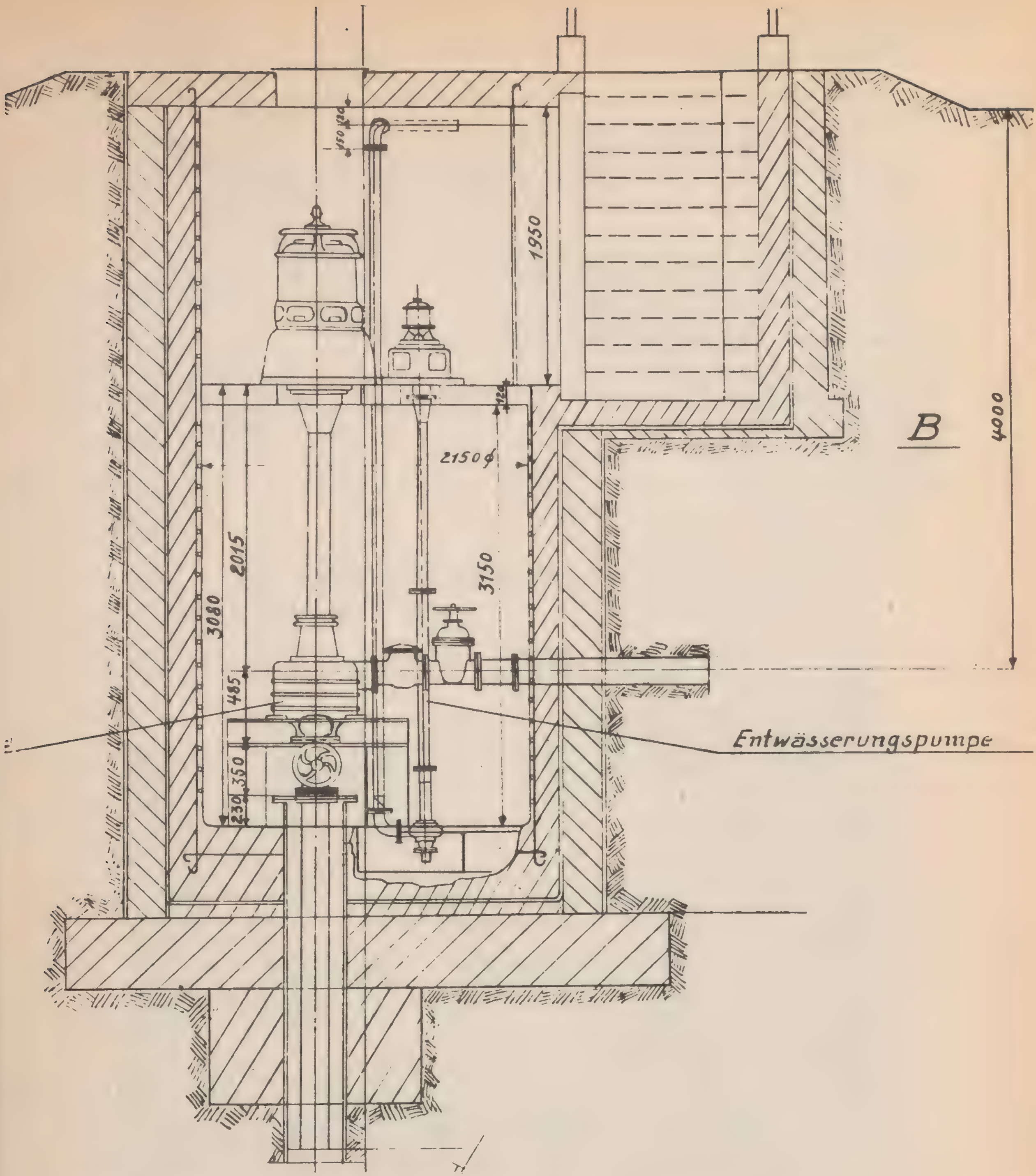


Fig. A-4-c, installation of deep well pump at
Eichwald-Kassel.

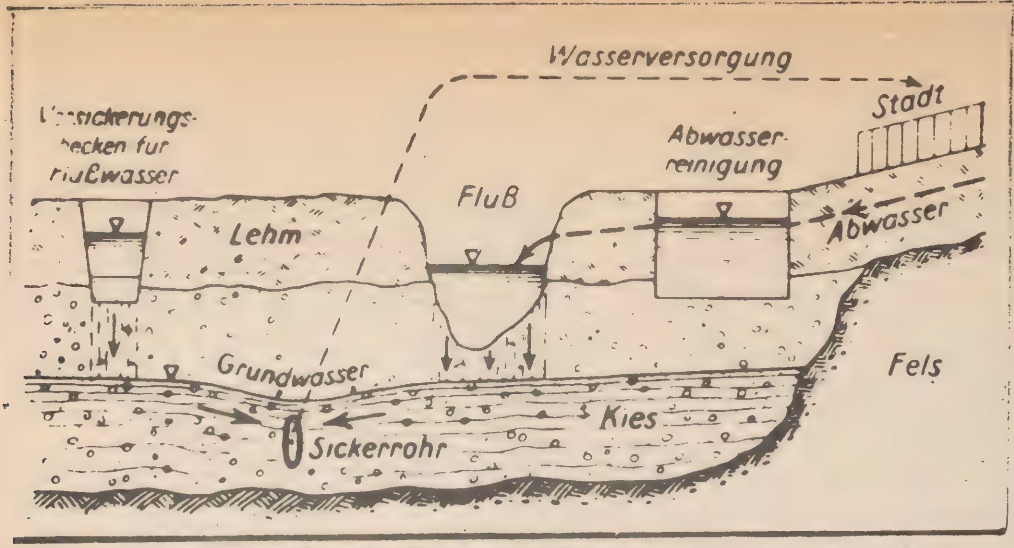


Fig. A-5-a, typical diagram showing how water is obtained in the Ruhr District by infiltration into galleries either directly from the river or from artificial sand filters supplied from the river.

Fig. A-5-b, construction of a typical infiltration gallery in Ruhr district.

Fig. A-5-c, sand filter for purification of Ruhr River water. Filtered water infiltrates into ground and is collected in galleries between filters.

Fig. A-5-d, repaired water and gas lines passing over trunk sewer in Essen. All were broken by a single bomb.

Fig. A-5-e, water mains destroyed by bombing in Essen.

Fig. A-5-f, community water point in downtown Essen. Supply from underground hydrant.

Fig. A-5-g, damage to elevated tank and booster pumping station in Essen.

Fig. A-5-h, bomb damage to underground reservoir in Essen. Note debris from tree dropped into reservoir.

Fig. A-6-a, Ruhrverband Ph Comparator.
Manufactured by [illegible]. [illegible]ssen.

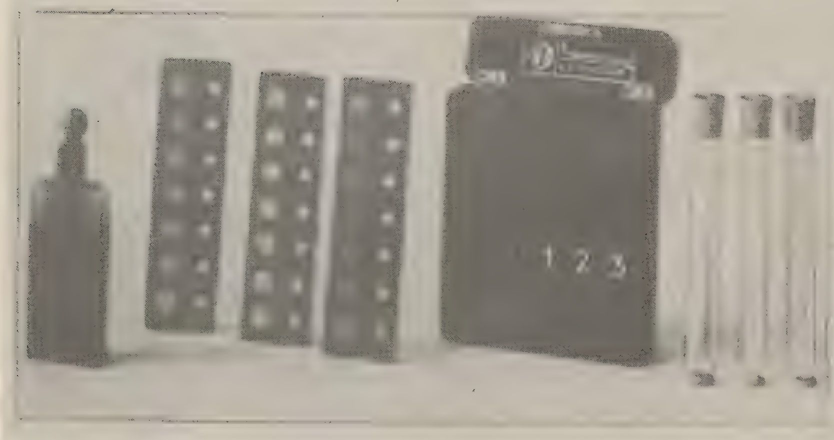


Fig. A-6-b, Ruhrverband Ph Comparator, showing indicator color slides, case and tubes for solutions and blank.

Fig. A-7-a, rapid sand roughing filter plant at Hagen.

Fig. A-7-b, pipe gallery at Hagen rapid sand filter plant BAMAG design.

A-7

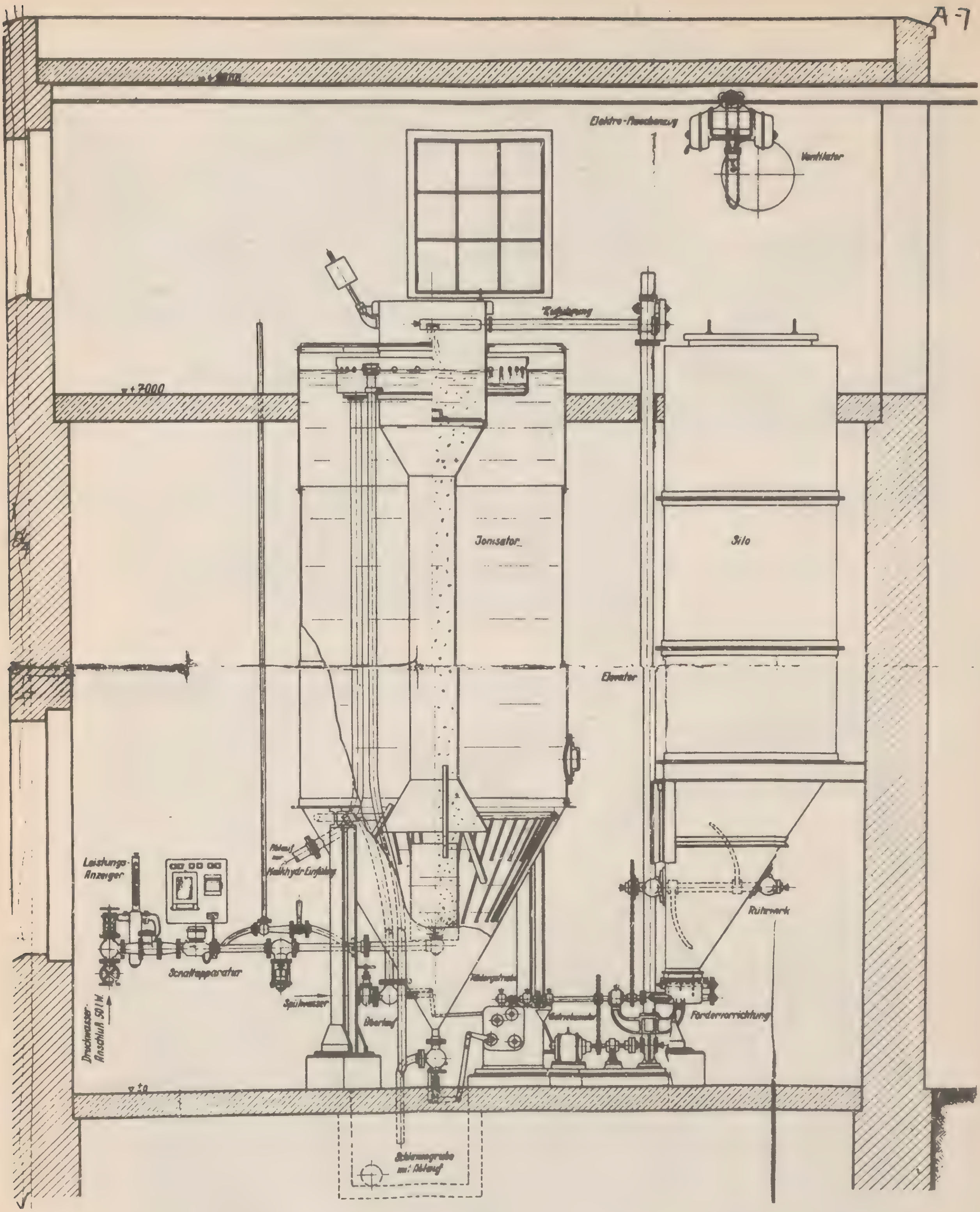


Fig. A-7-c, Bucher system of treating water for reduction of CO_2 - Hagen.

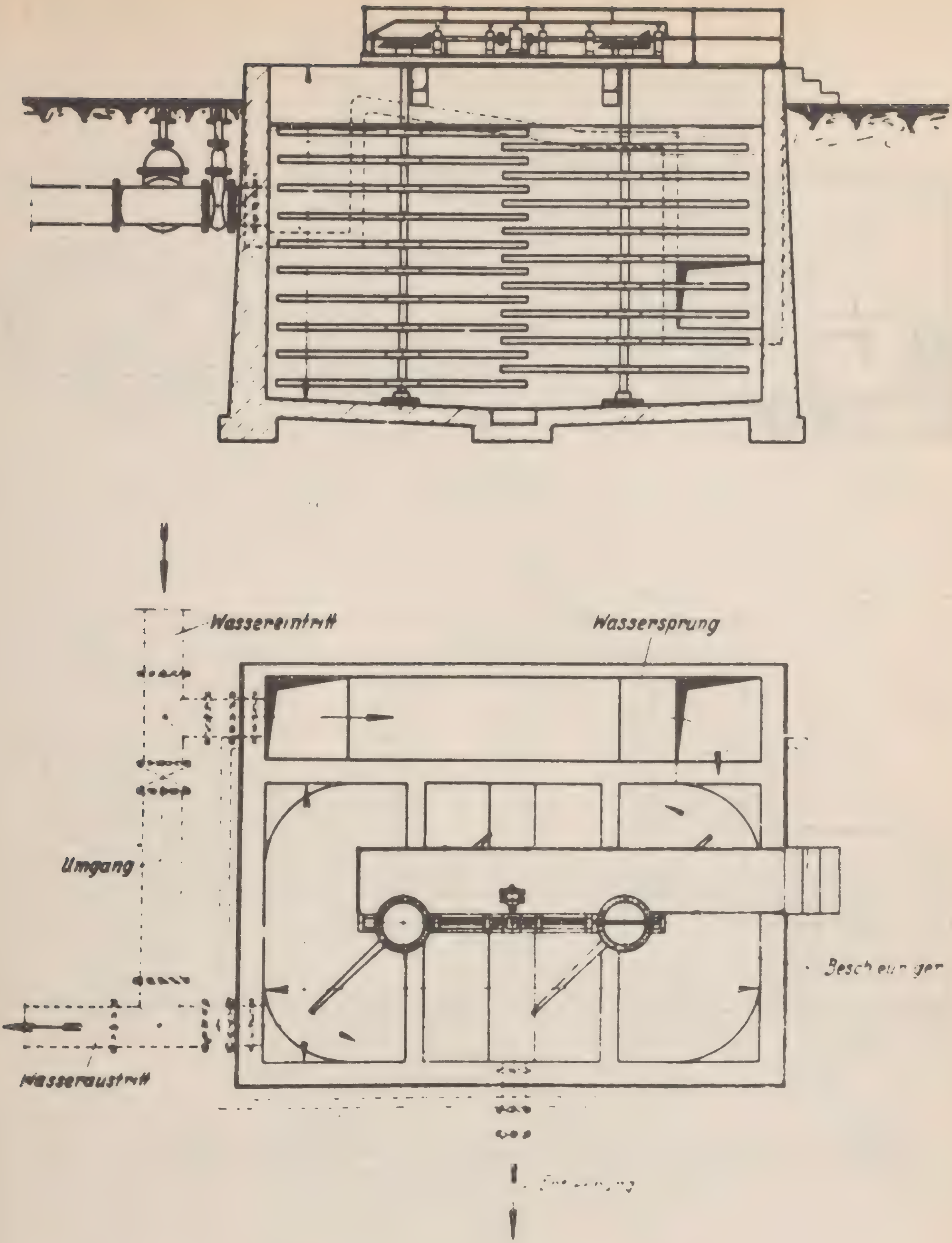


Fig. A-7-d, vertical mixers of type used at Hengstey Filter Plant, Hagen.

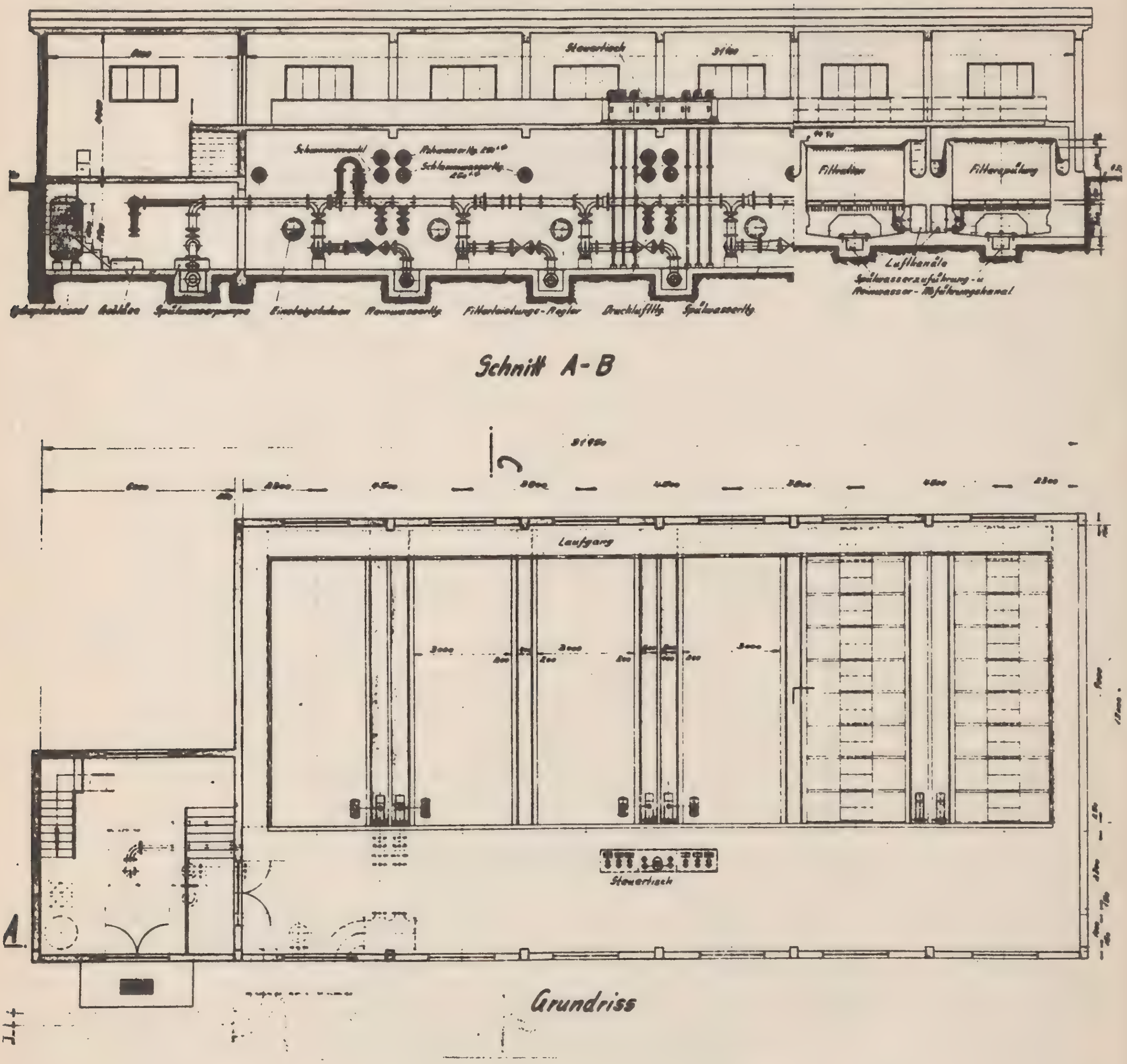


Fig. A-7-e, elevation and section of WABOG rapid sand filter of type operated at Halspetalsperr - city of Hagen.

Fig. A-8-a, damage to the side wall of slow sand filter-Bremen. Note destroyed camouflage in background.

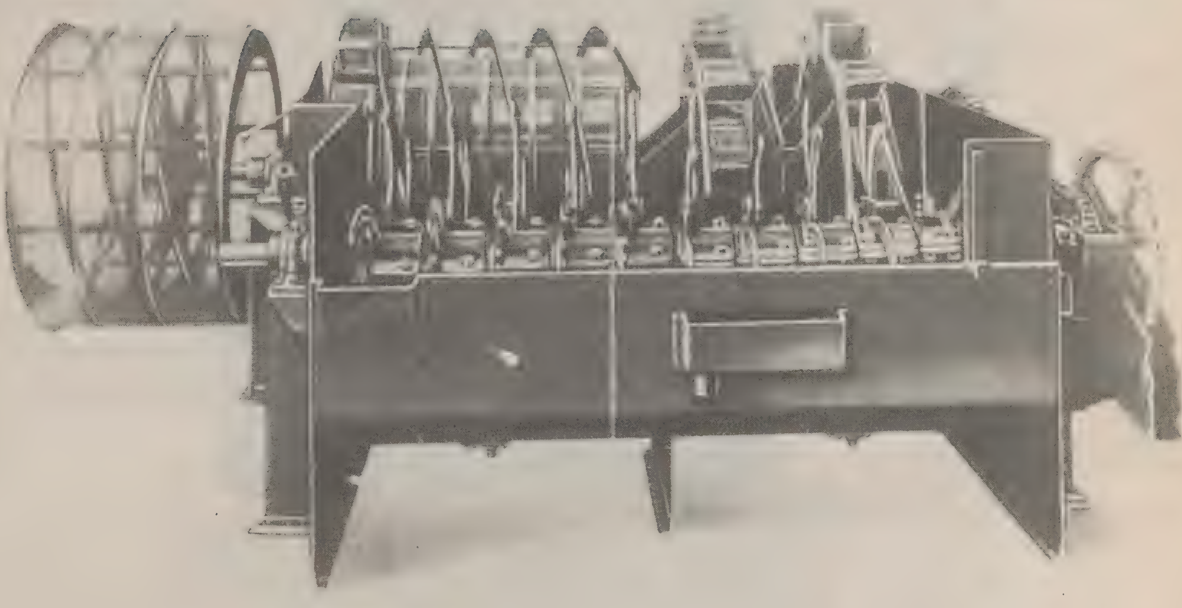


Fig. A-8-b, Excelsior mechanical sand washing machine.

Fig. A-8-c, elevated water tank - Bremen.

Fig. A-8-d, destruction to roof of elevated water tank - Bremen.

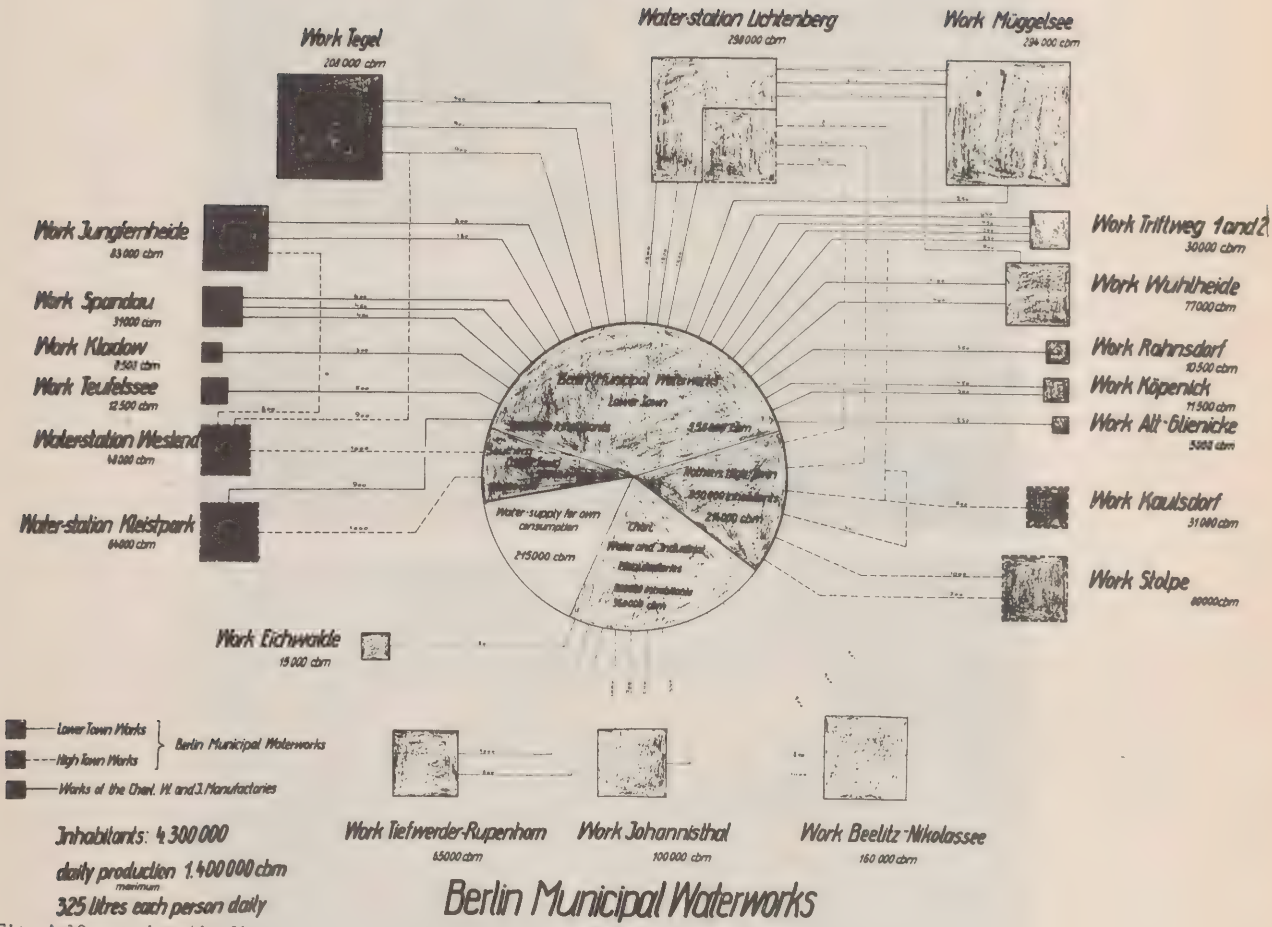
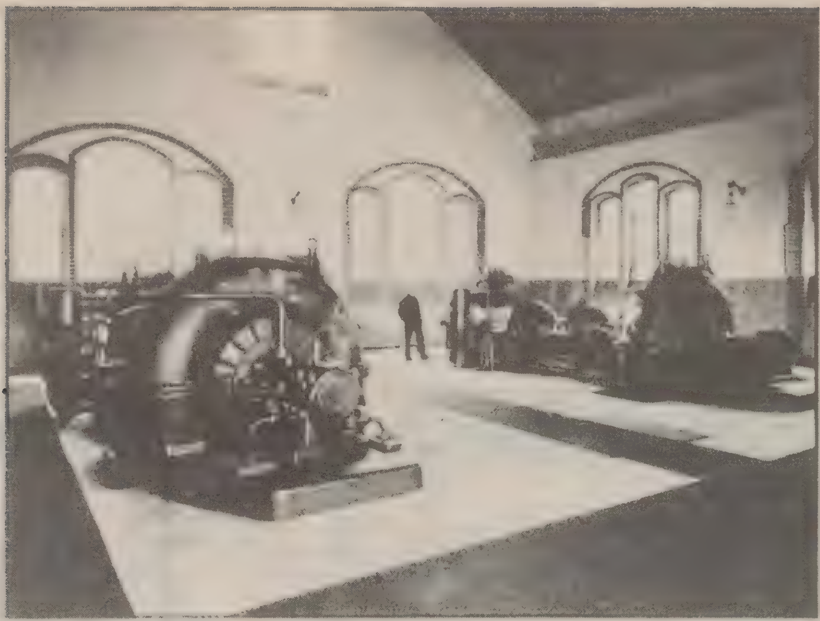


Fig. A-10-a, schematic diagram of Berlin water works system - 1940.

Fig. A-11-a, distribution basins of aerating plant - Tegel-Berlin.



ig. A-12-a, steam turbines at
ichtenberg high pressure pumping
station - Berlin.

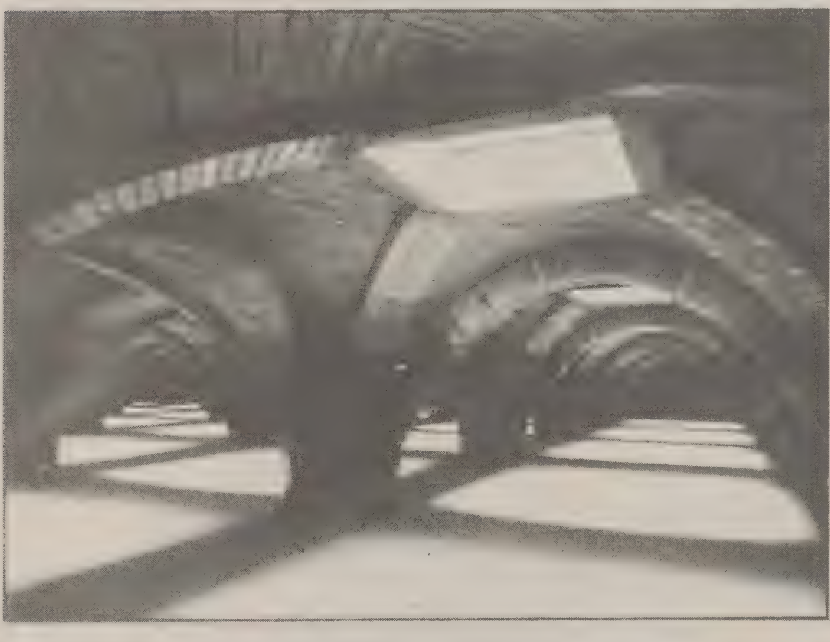


Fig. A-12-b, sand filter for lake water -
Berlin.

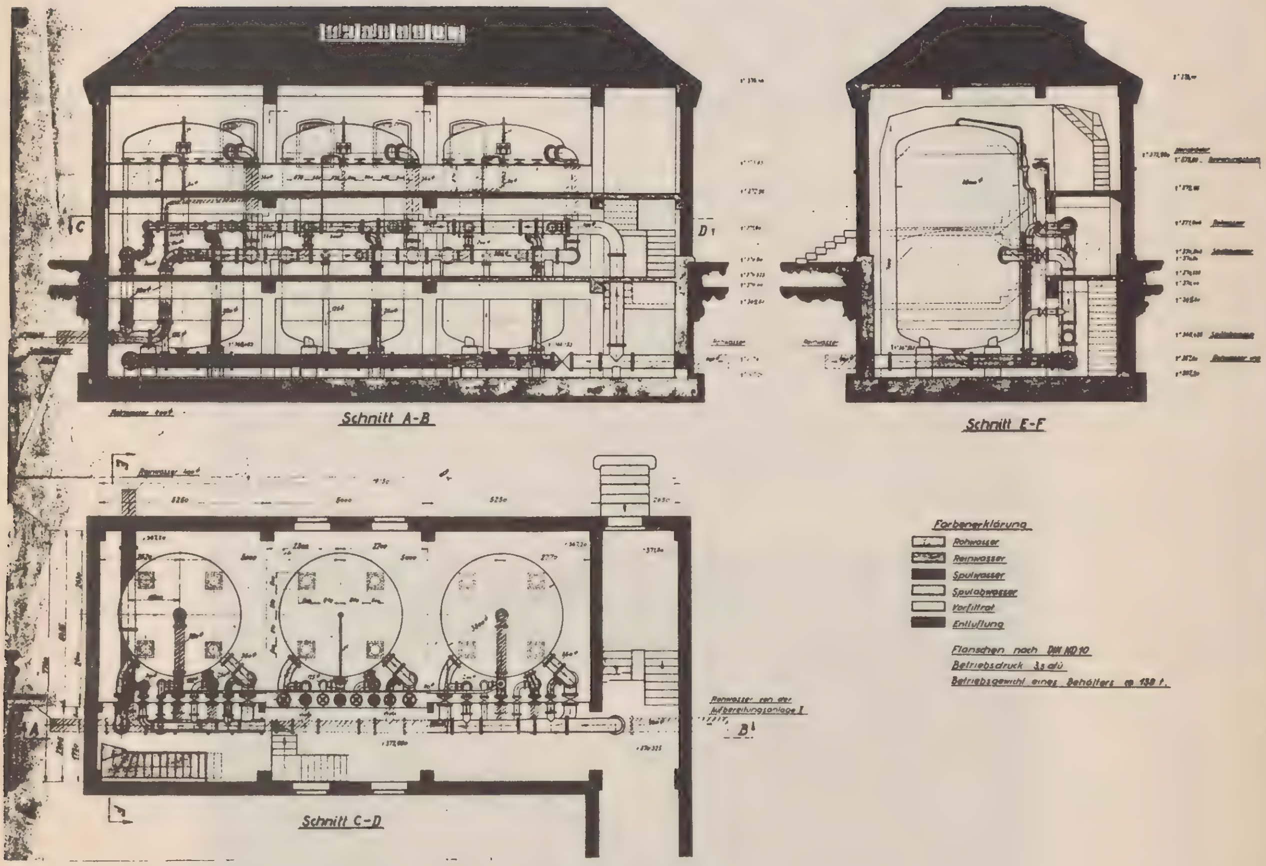


Fig. A-13-a, Bamag double decked pressure filters at munitions plant - Ebenhausen.

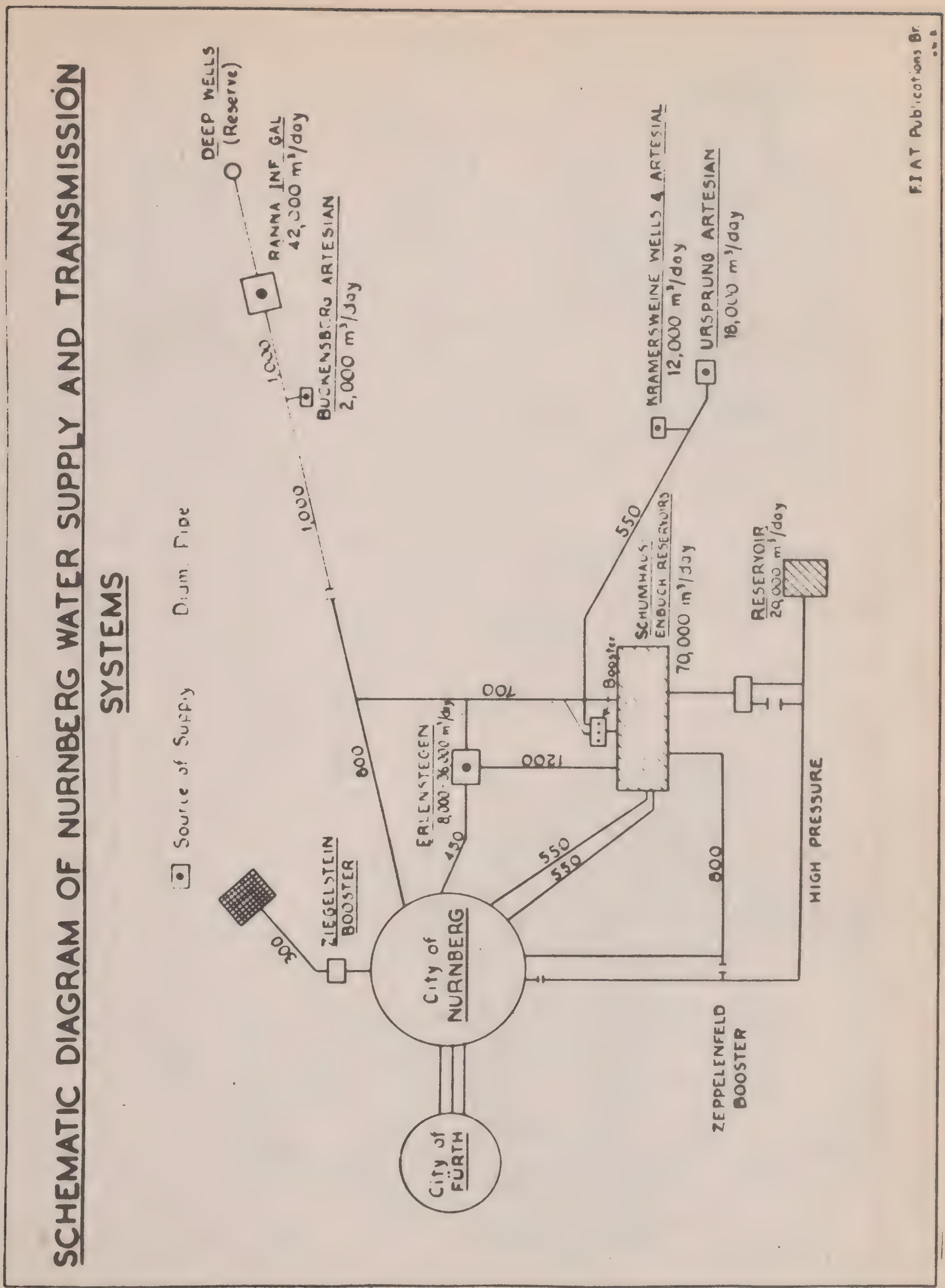

SCHEMATIC DIAGRAM OF NURNBERG WATER SUPPLY AND TRANSMISSION SYSTEMS
Source of Supply
Diam. Pipe
DEEP WELLS (Reserve)
RANNA INF. GAL 42,000 m^3/day
2,000 m^3/day
KRAMERSWEINE WELLS & ARTESIAN 12,000 m^3/day
URSPRUNG ARTESIAN 18,000 m^3/day
70,000 m^3/day
Booster
RESERVOIR 20,000 m^3/day
ERLENSTEGEN 8,000-36,000 m^3/day
ZIEGELSTEIN BOOSTER
City of NURNBERG
City of FÜRTH
ZEPPELENFELD BOOSTER
HIGH PRESSURE
1,000
1,000
800
700
1200
550
550
550
450
800
300
F.I.A.T. Publications Br.

Fig. A-14-a.

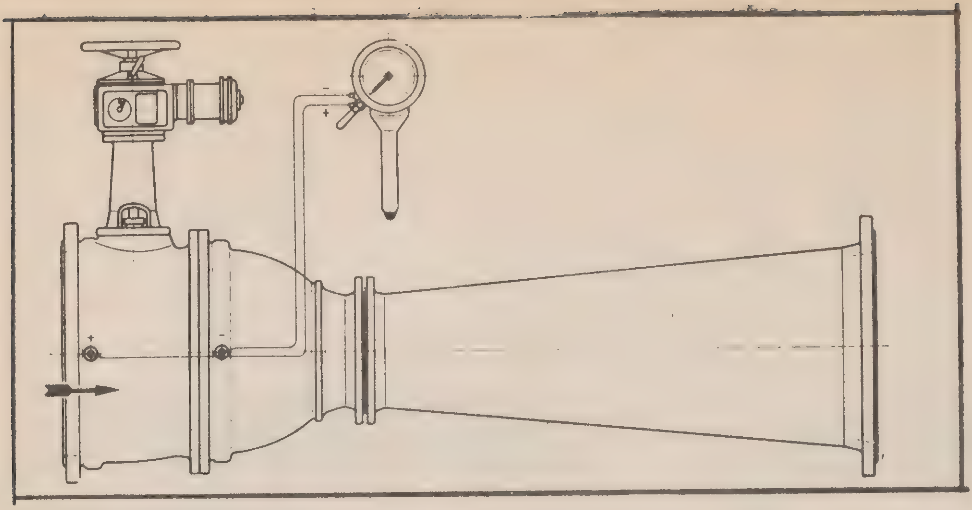


Fig. 15-a, electrically operated streamlined needle valve.

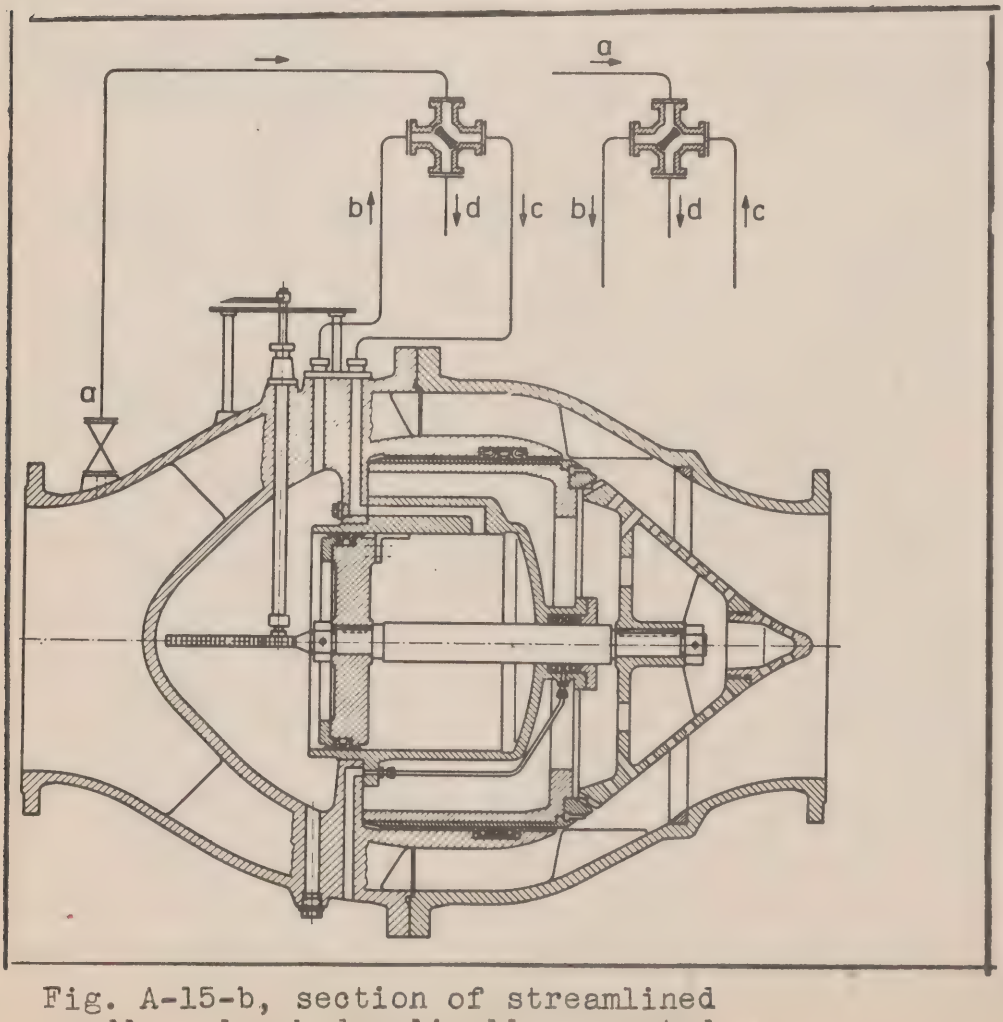


Fig. A-15-b, section of streamlined needle valve hydraulically operated.

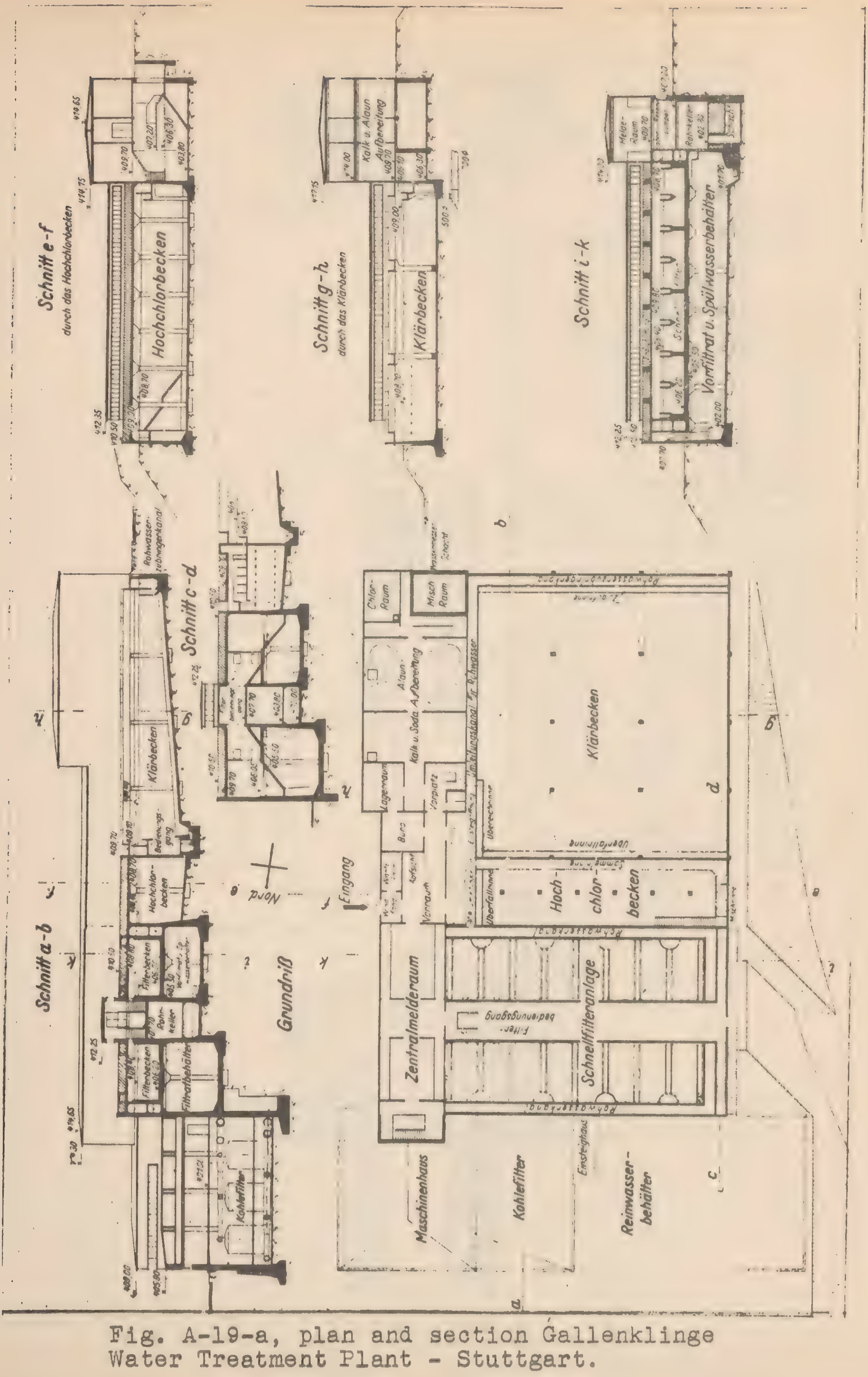


Fig. A-19-a, plan and section Gallenklinge
Water Treatment Plant - Stuttgart.

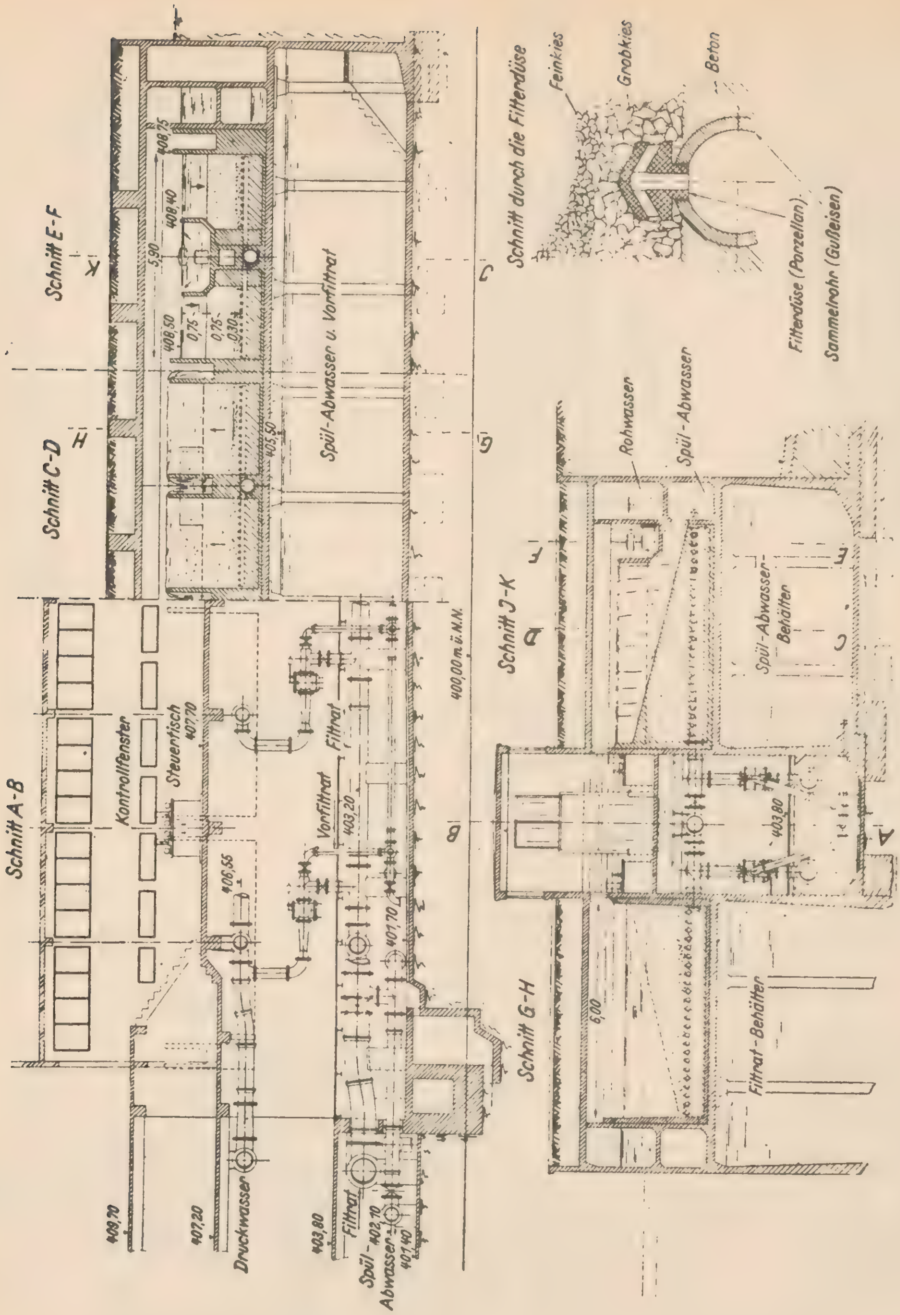


Fig. A-19-b, sections through de-chlorinating filter at Gallenklinge plant - Stuttgart.

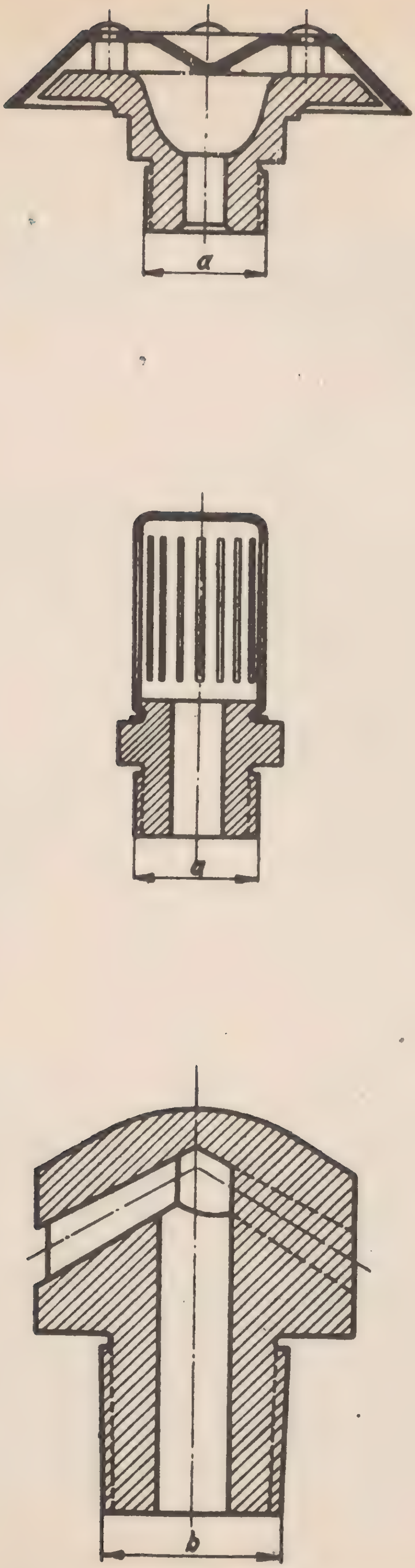


Fig. A-20-a, filter underdrain nozzles
for backwash with water only - Bamag.

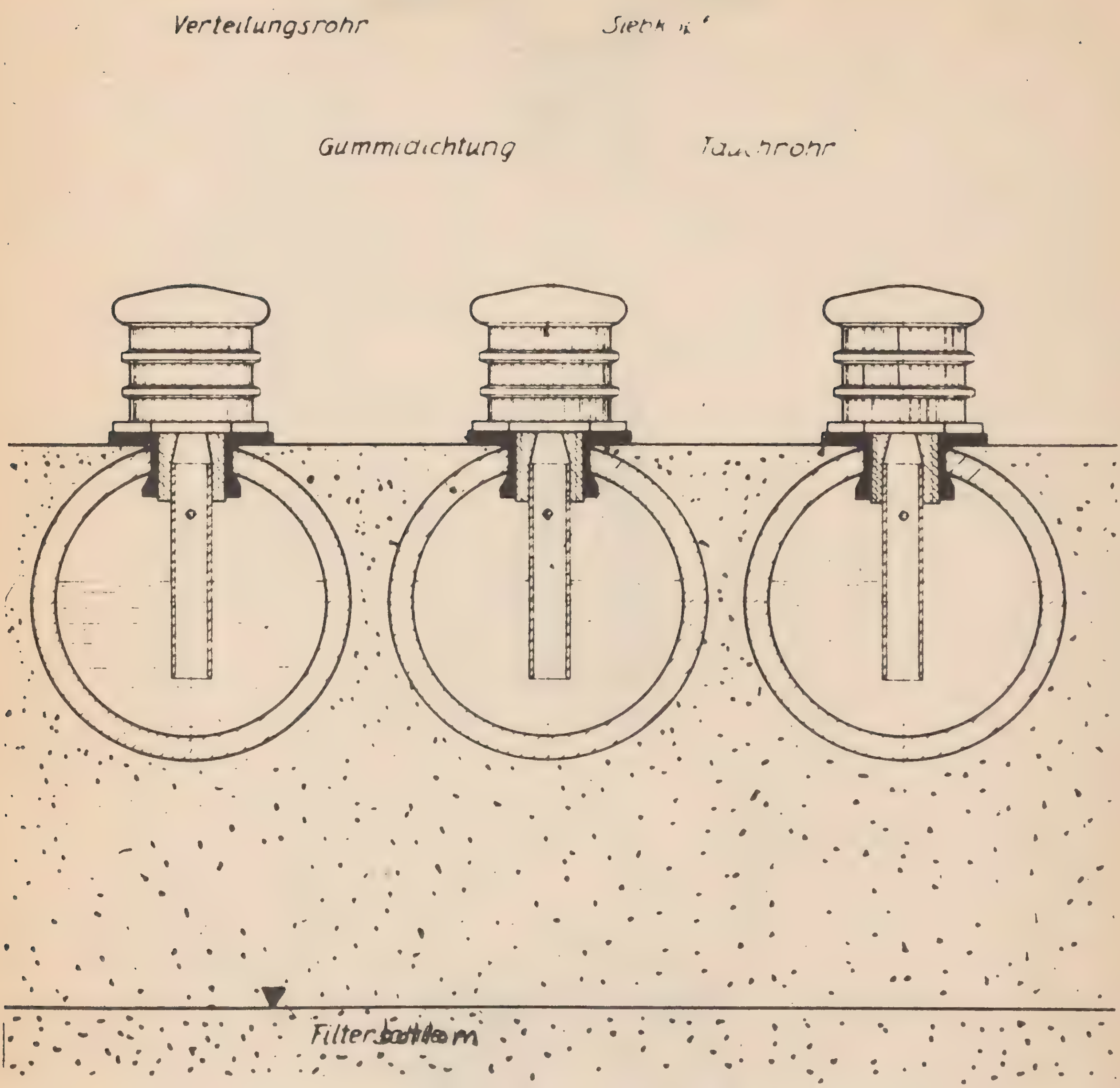


Fig. A-20-b, filter underdrain nozzles for backwash with water and air - Bamag.

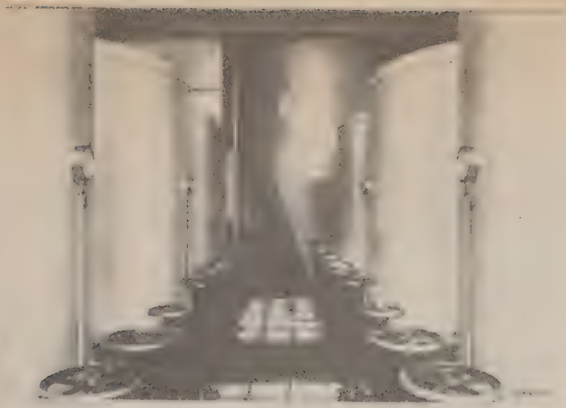


Fig. A-20-c, pressure filter.

Fig. A-20-d, pressure filter with water and air wash.

Fig. A-20-e, two stage filters with stirring equipment.

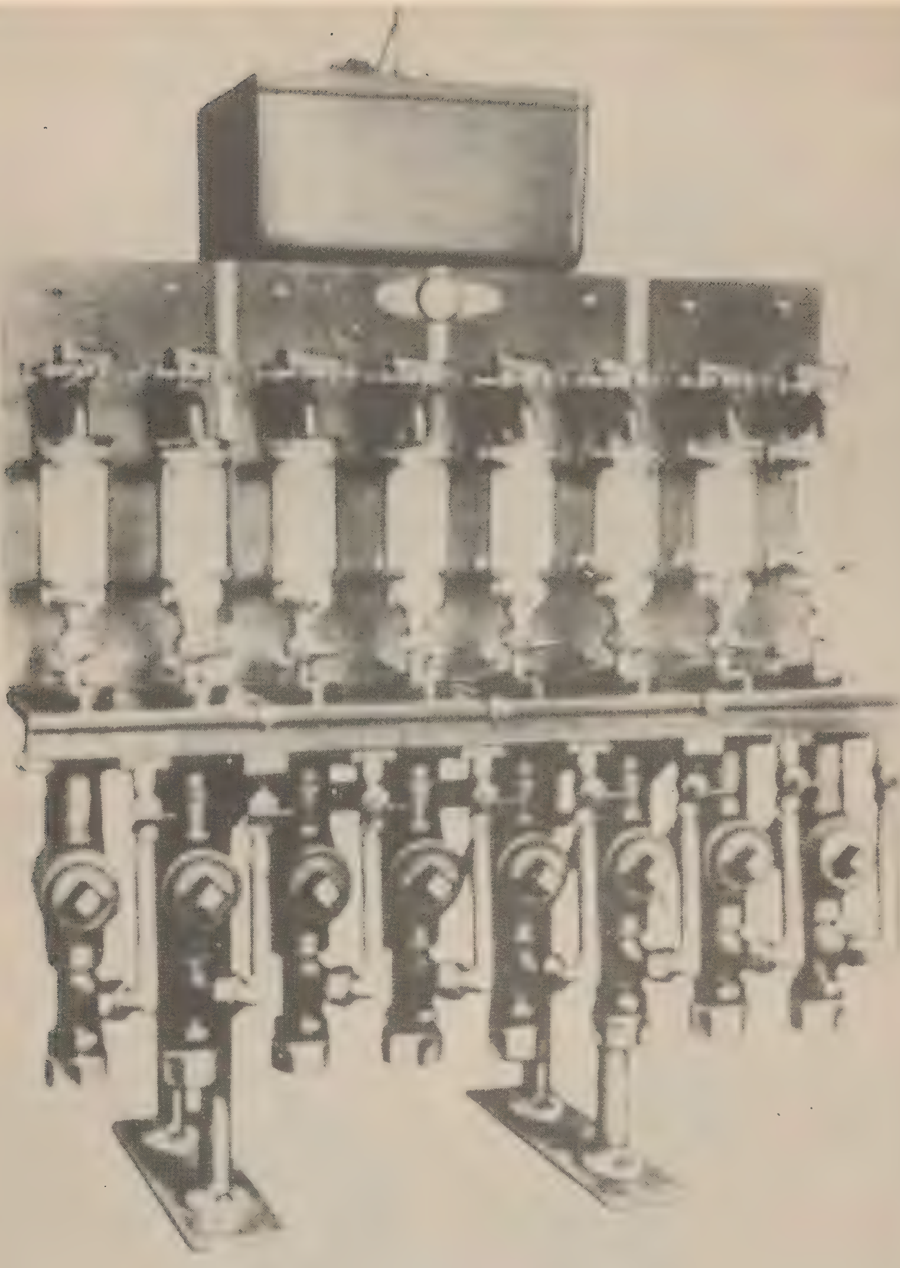


Fig. A-20-f, battery of eight solution feed calibrating units with hard rubber pipe and fittings - Bamag.

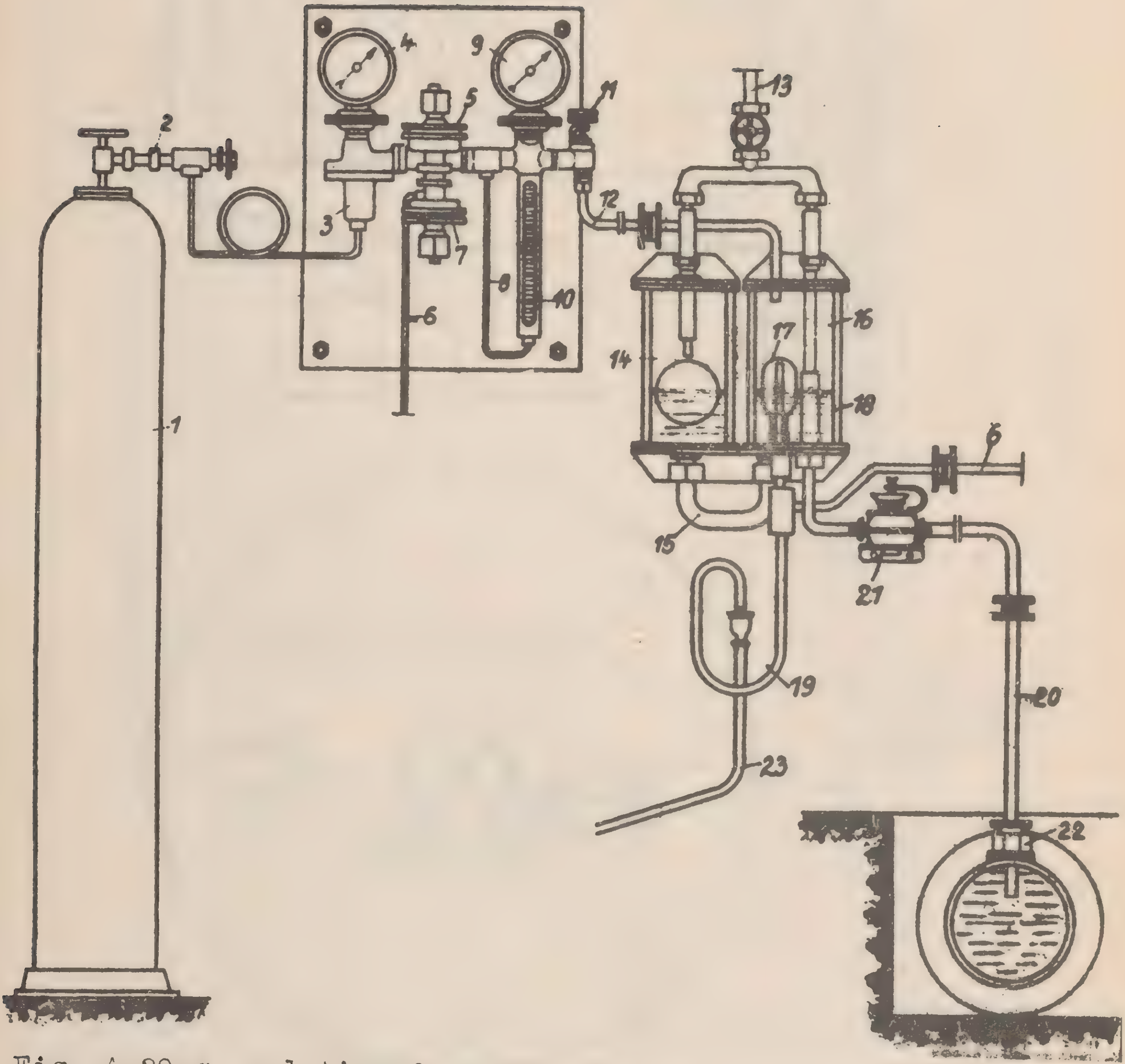


Fig. A-20-g, solution feed chlorinator - Bamag.

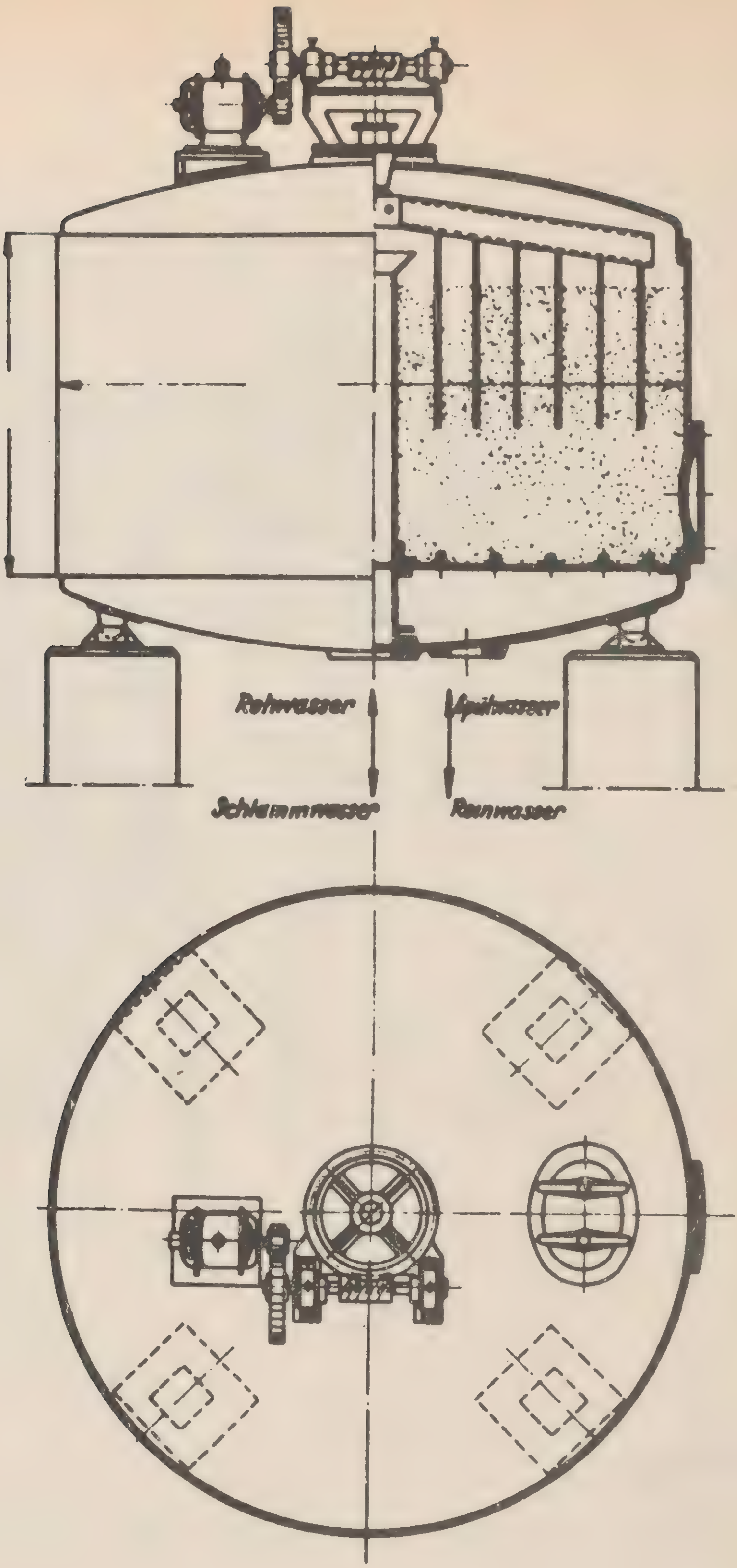


Fig. A-20-h, pressure filter with motor driven rake - Bamag.

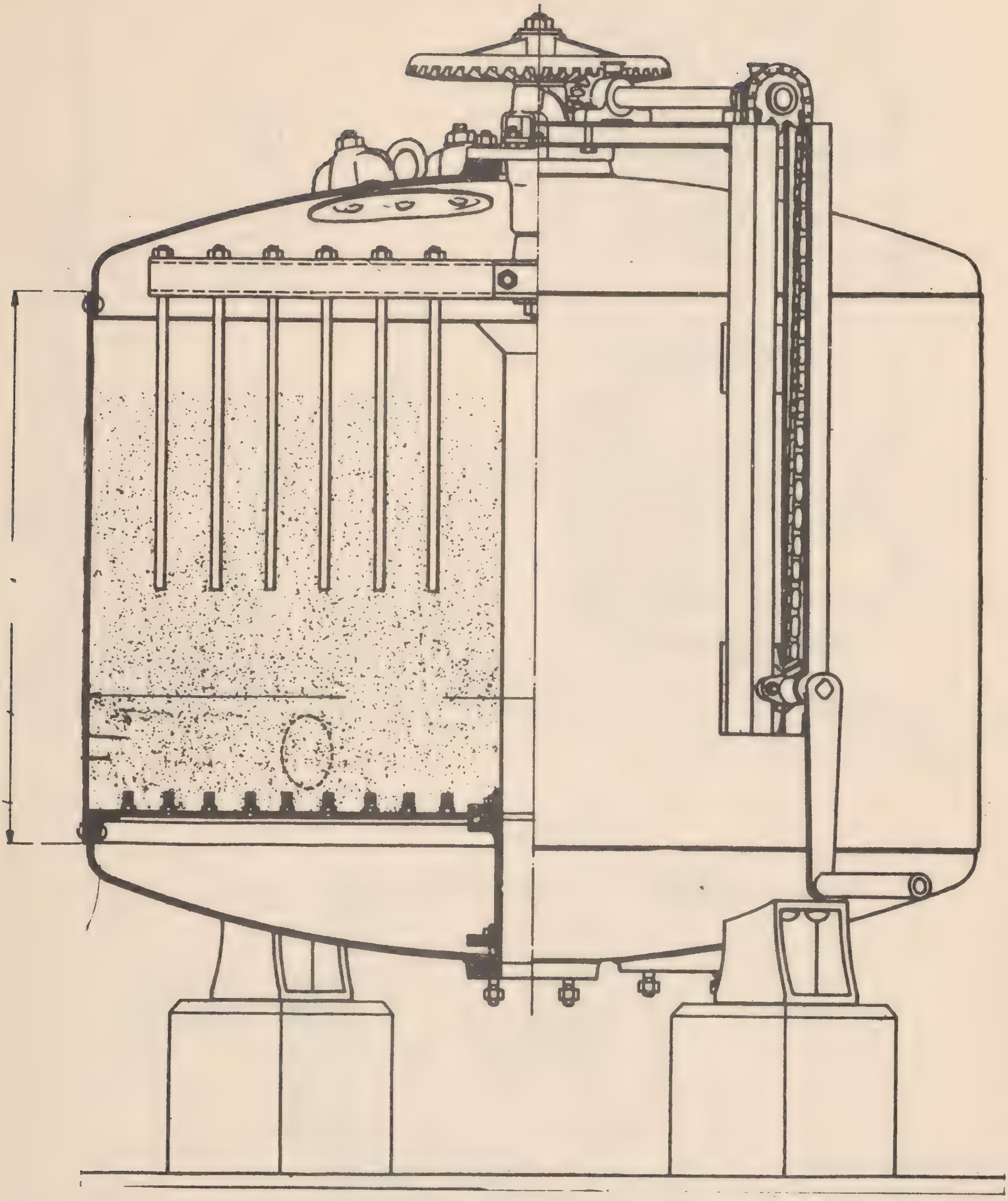


Fig. A-20-i, pressure filter with hand operated rake - Bamag.

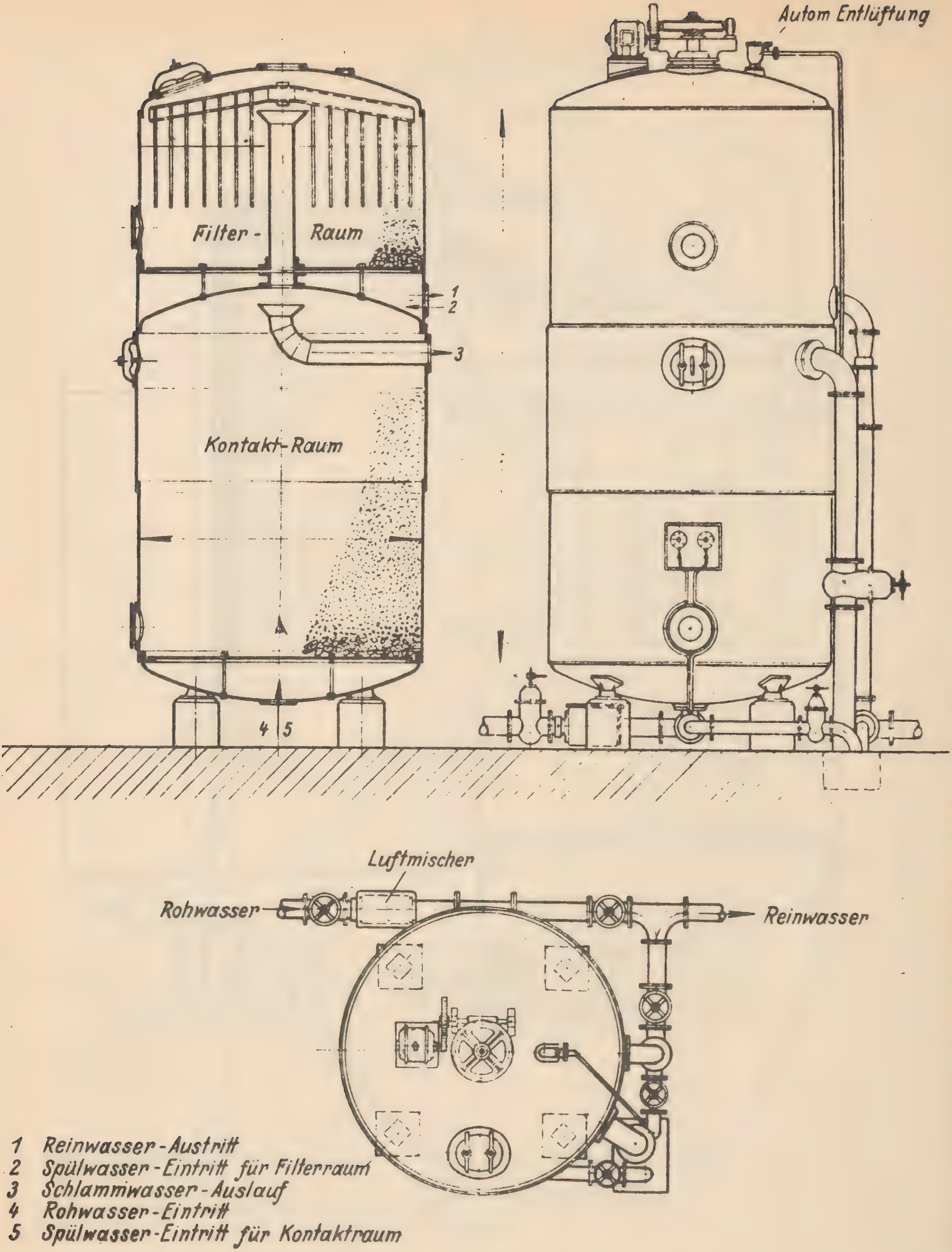


Fig. A-20-j, two phase iron removal unit - Bamag.

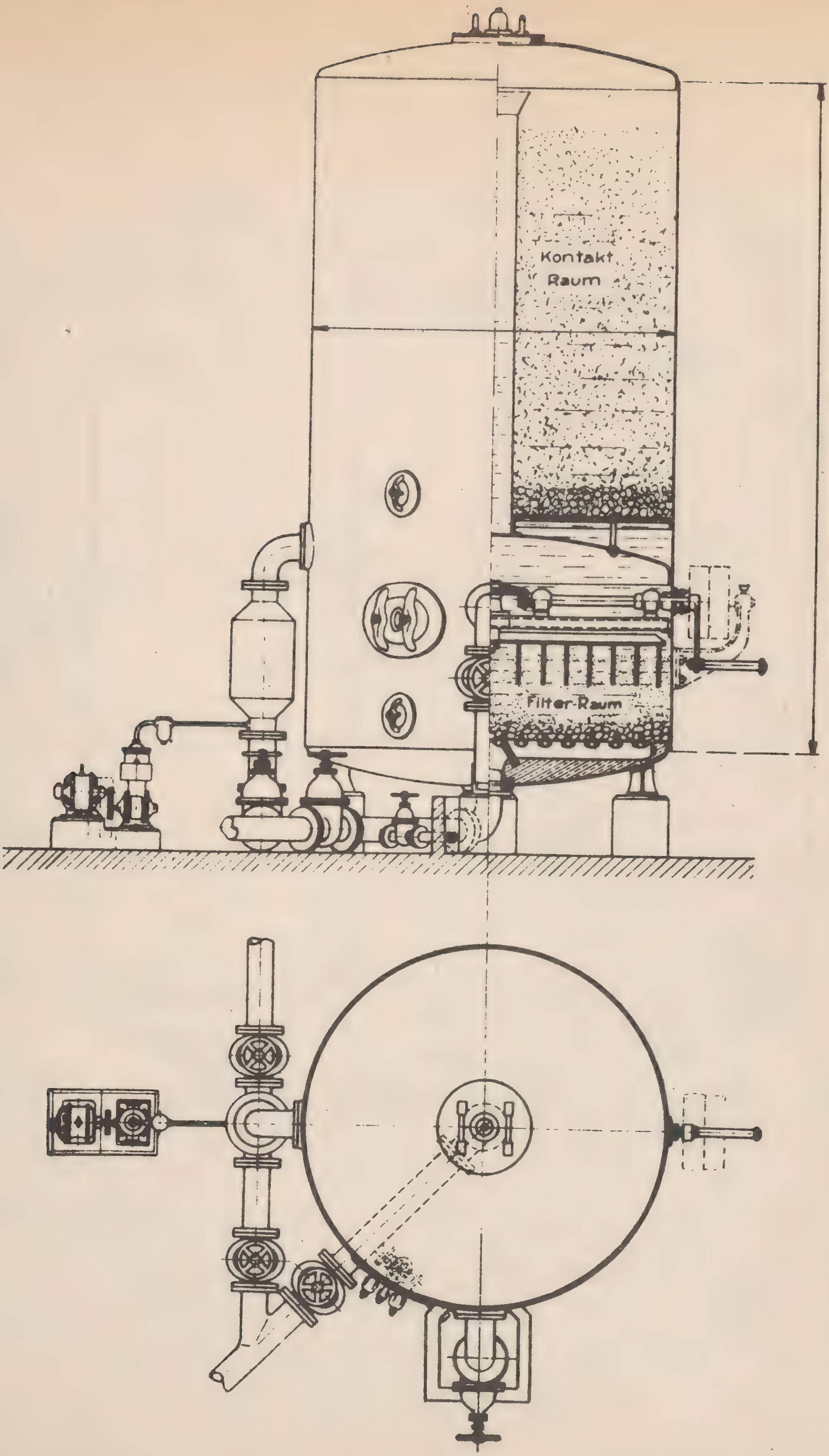


Fig. A-20-k, two phase iron removal unit - Bamag.

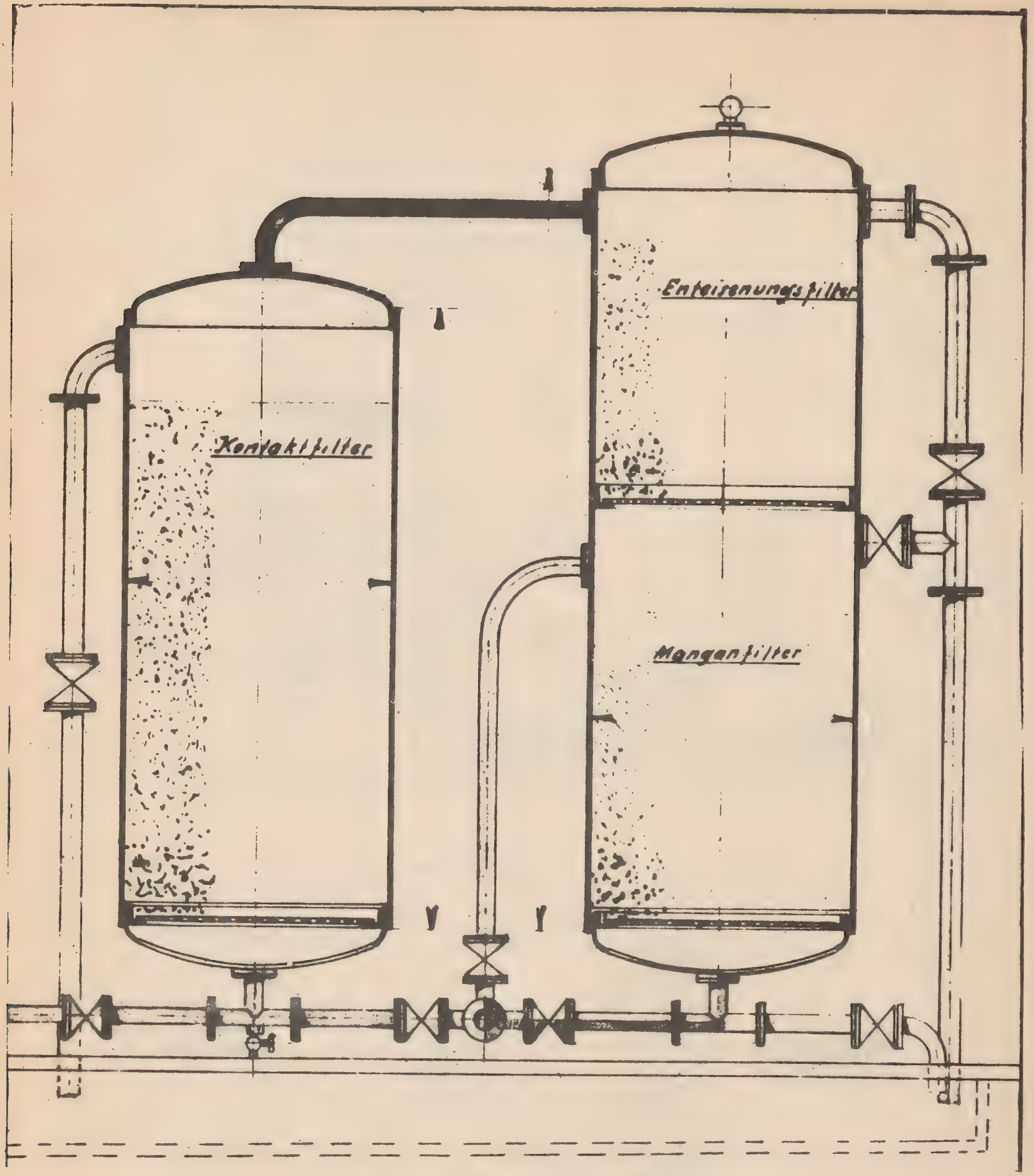


Fig. A-20-1, iron and manganese removal pressure filter units with contact filter - Bamag.

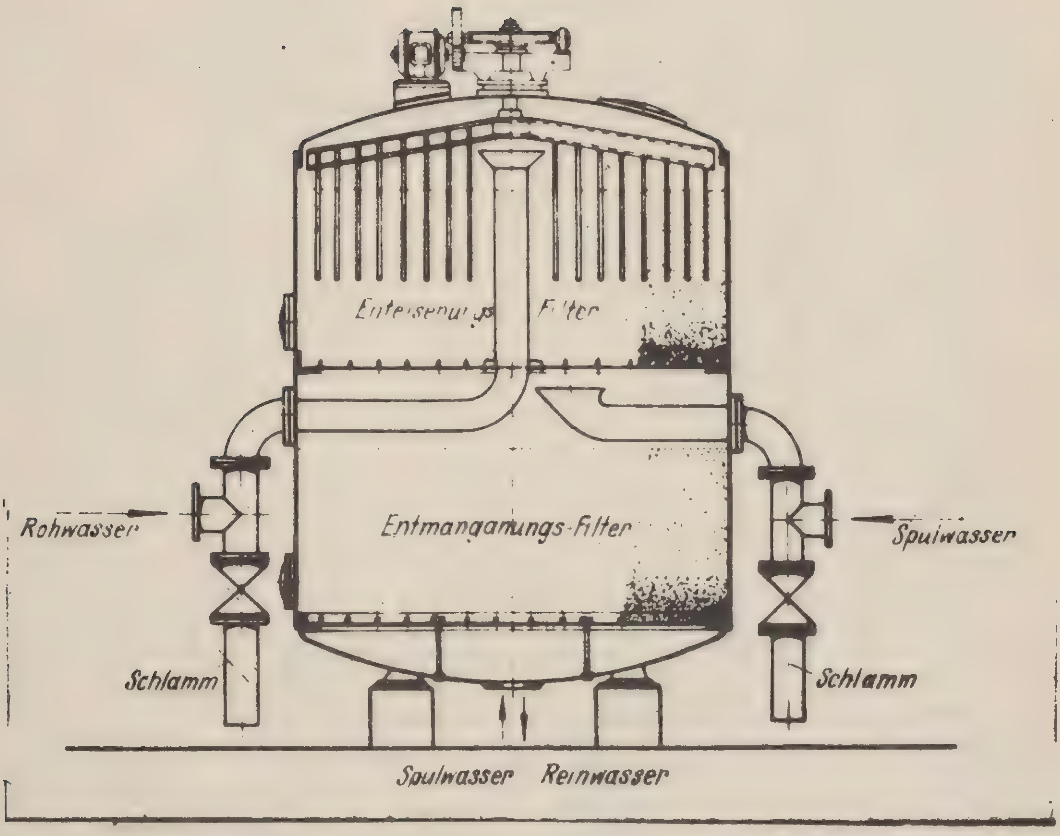


Fig. A-20-m, iron and manganese removal -
Bamag.

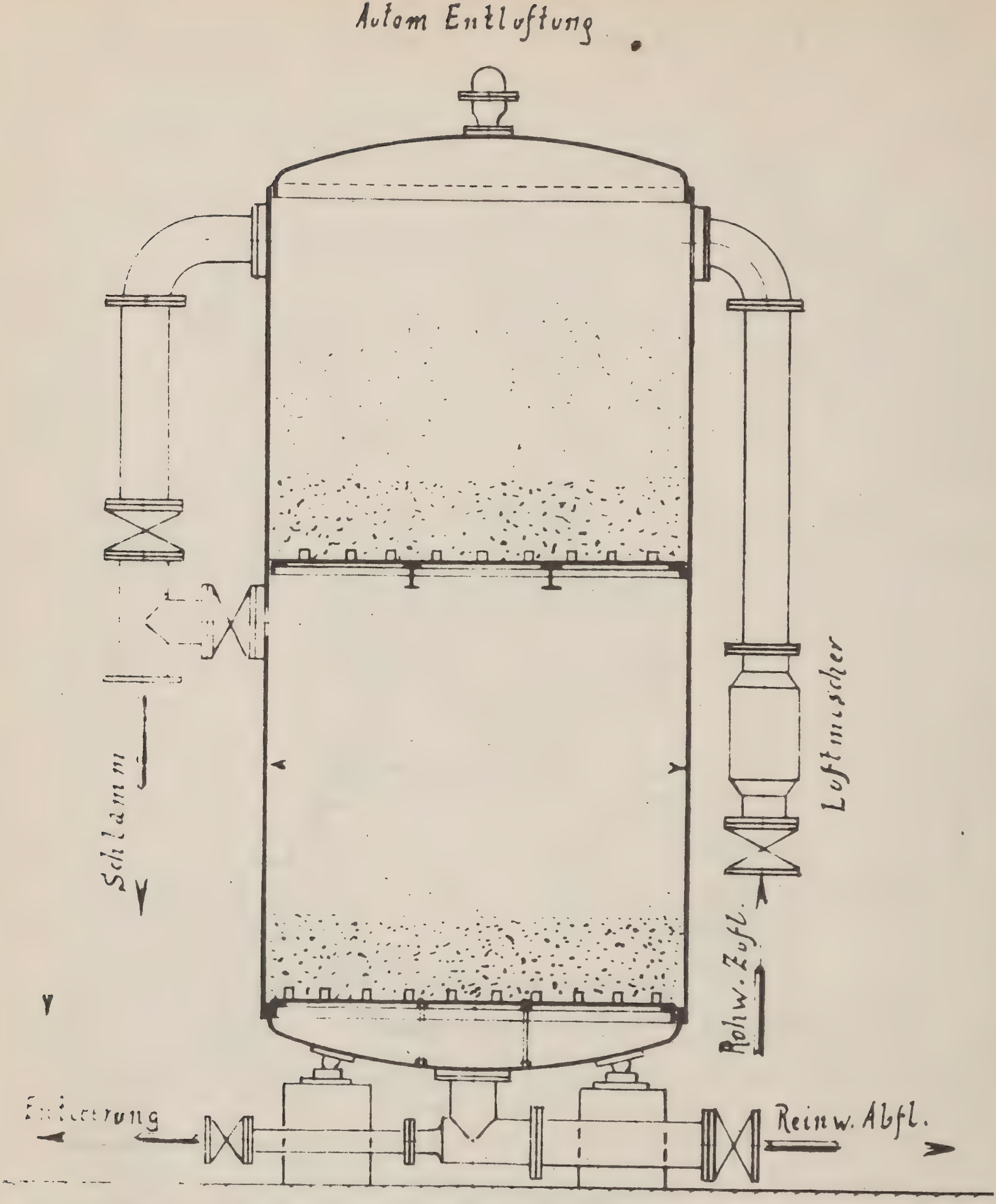


Fig. A-20-n, combination iron and manganese removal unit - Bamag.

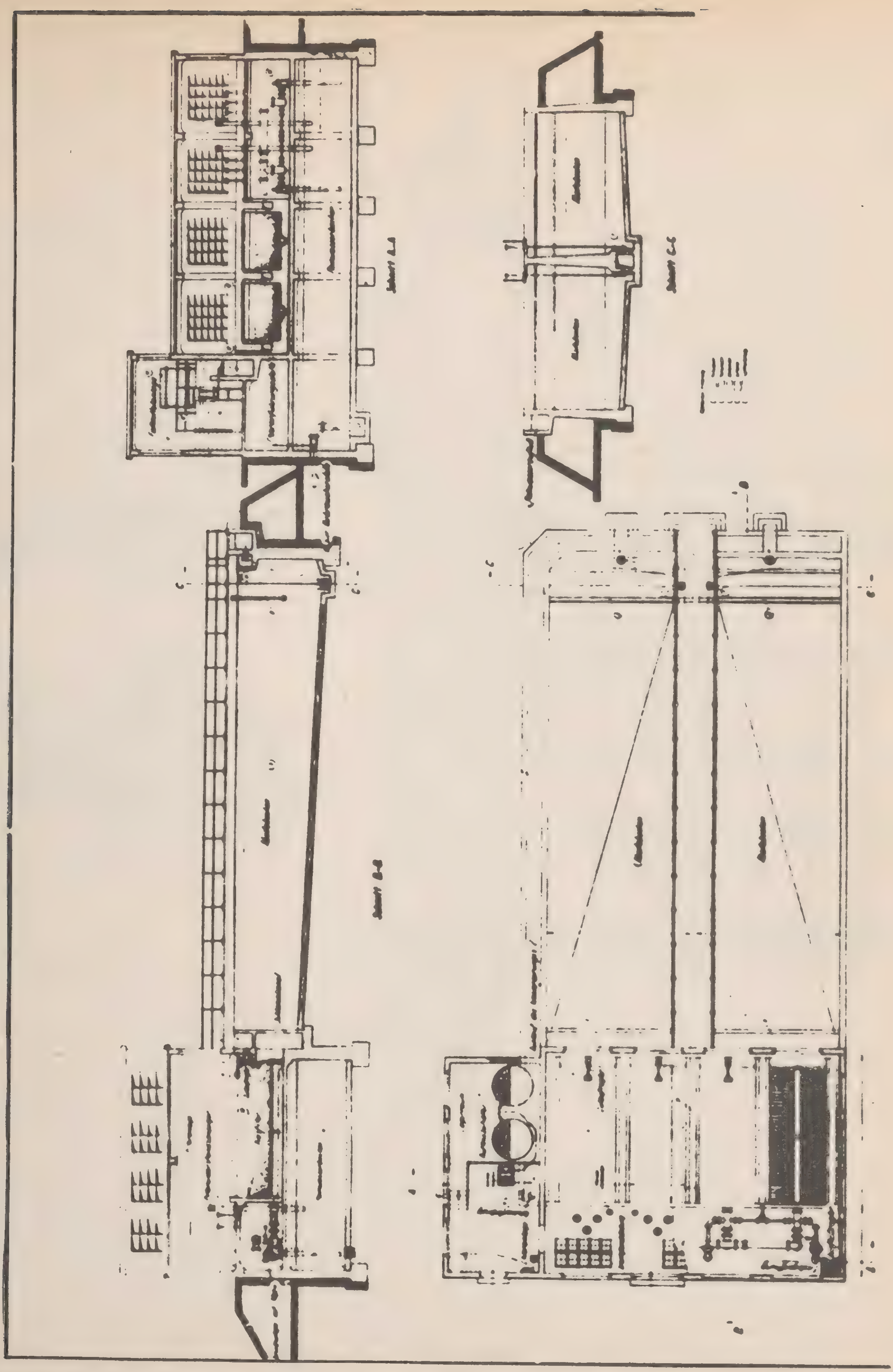


Fig. A-20-o, rapid sand filter with settling unit.

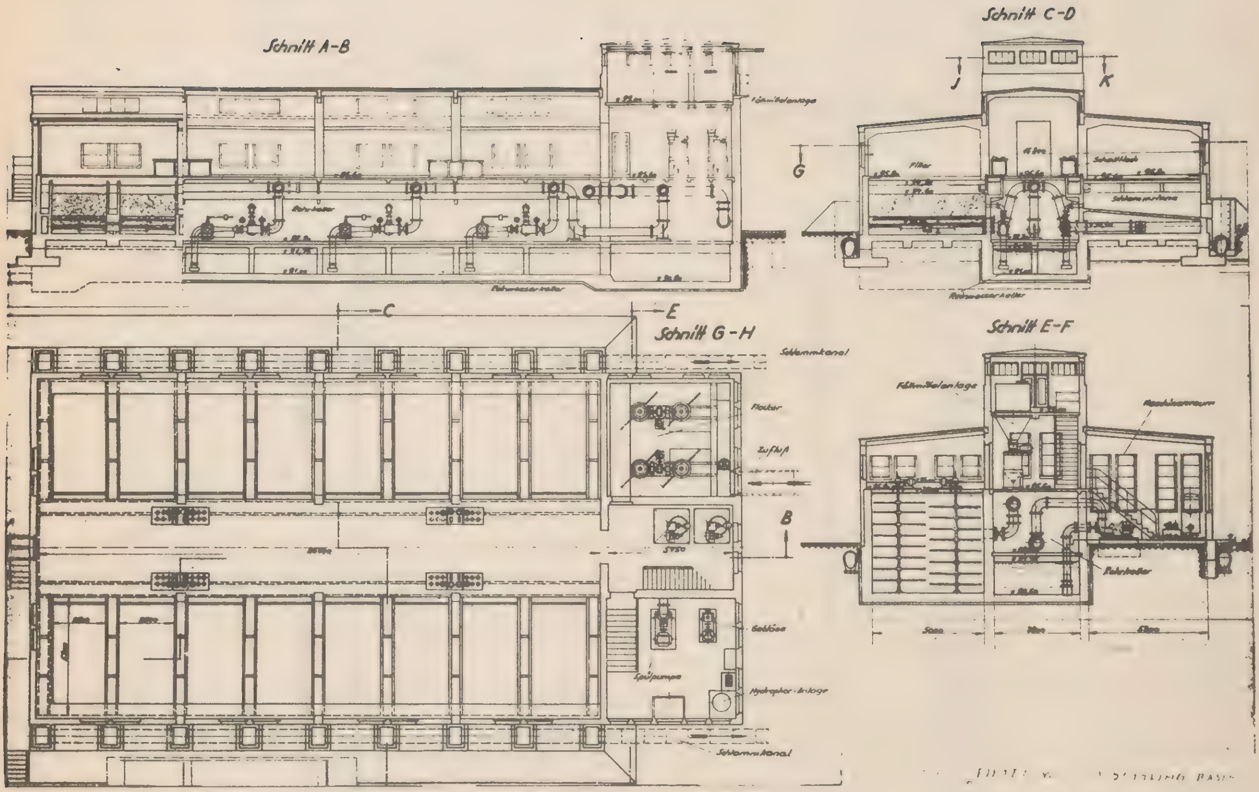


Fig. A-20-p, rapid sand filter without settling basin.

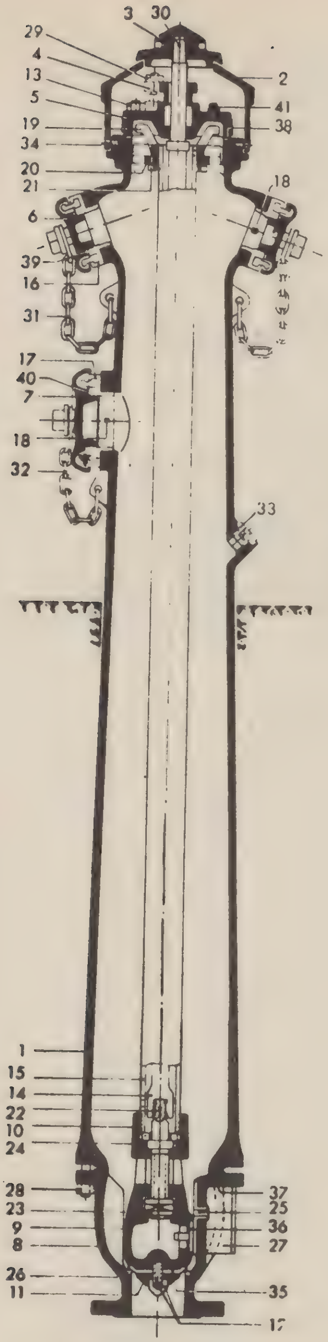


Fig. A-21-a, typical above ground hydrant used in Germany.

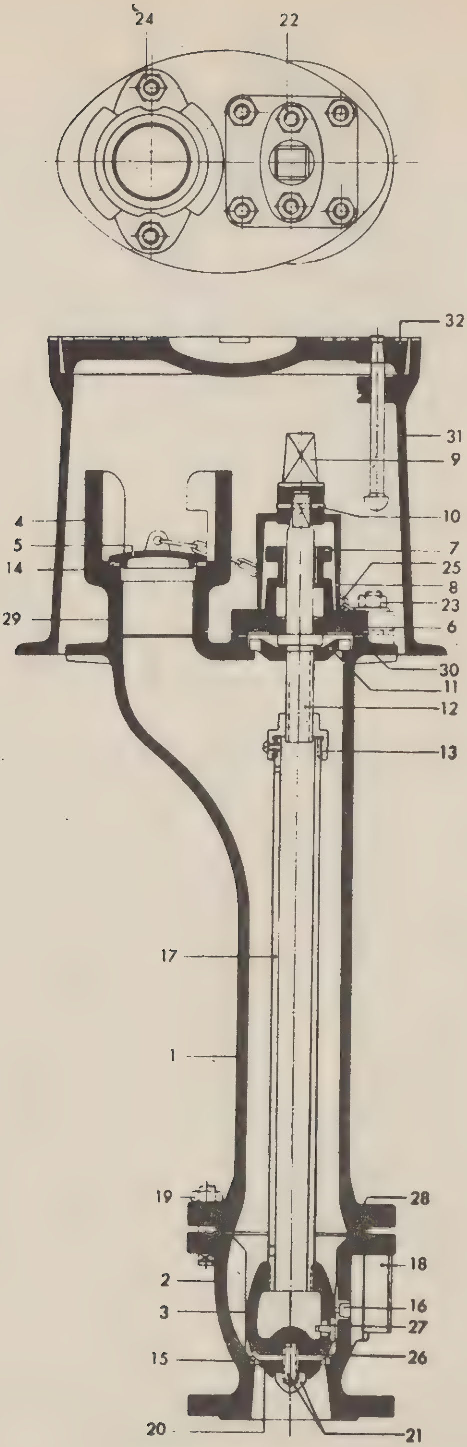


Fig. A-21-b, typical underground hydrant used in Germany.

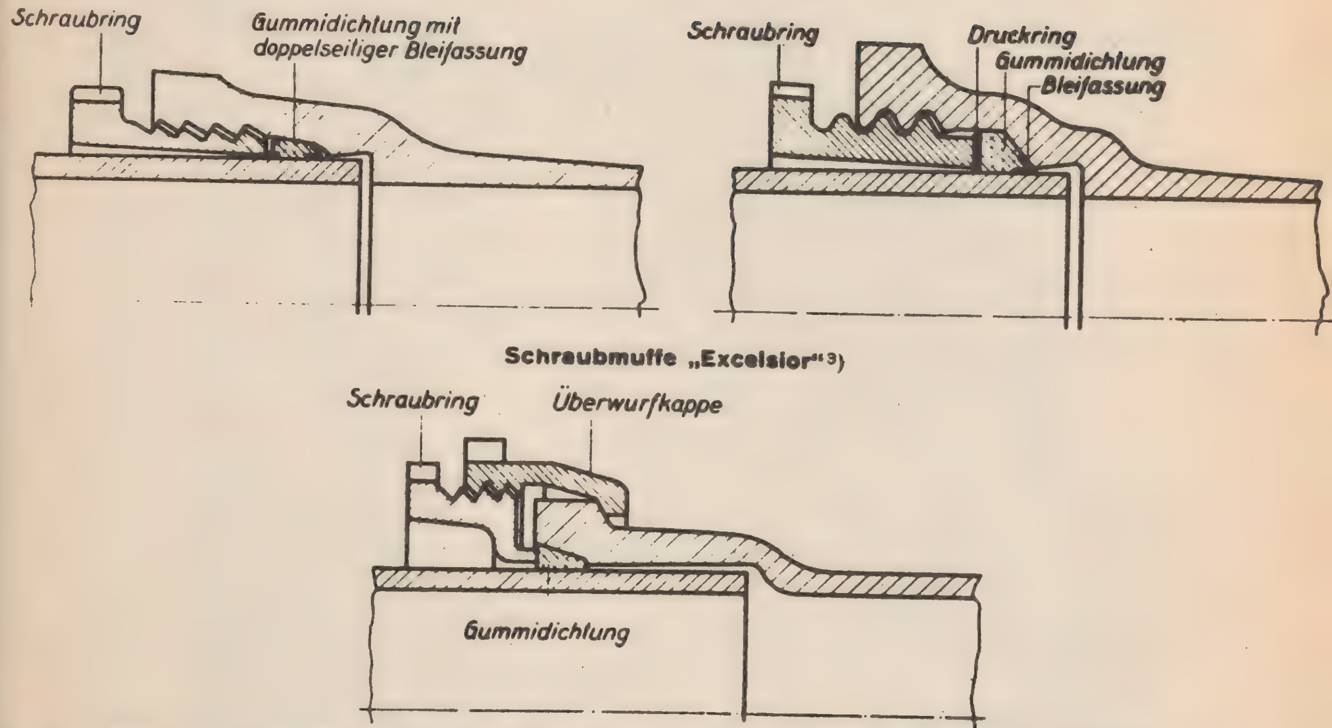


Fig. A-21-c, types of cast iron pipe joints in Germany using threaded nipple insert.

Fig. A-81-d, reinforced concrete pressure pipe after test failure.

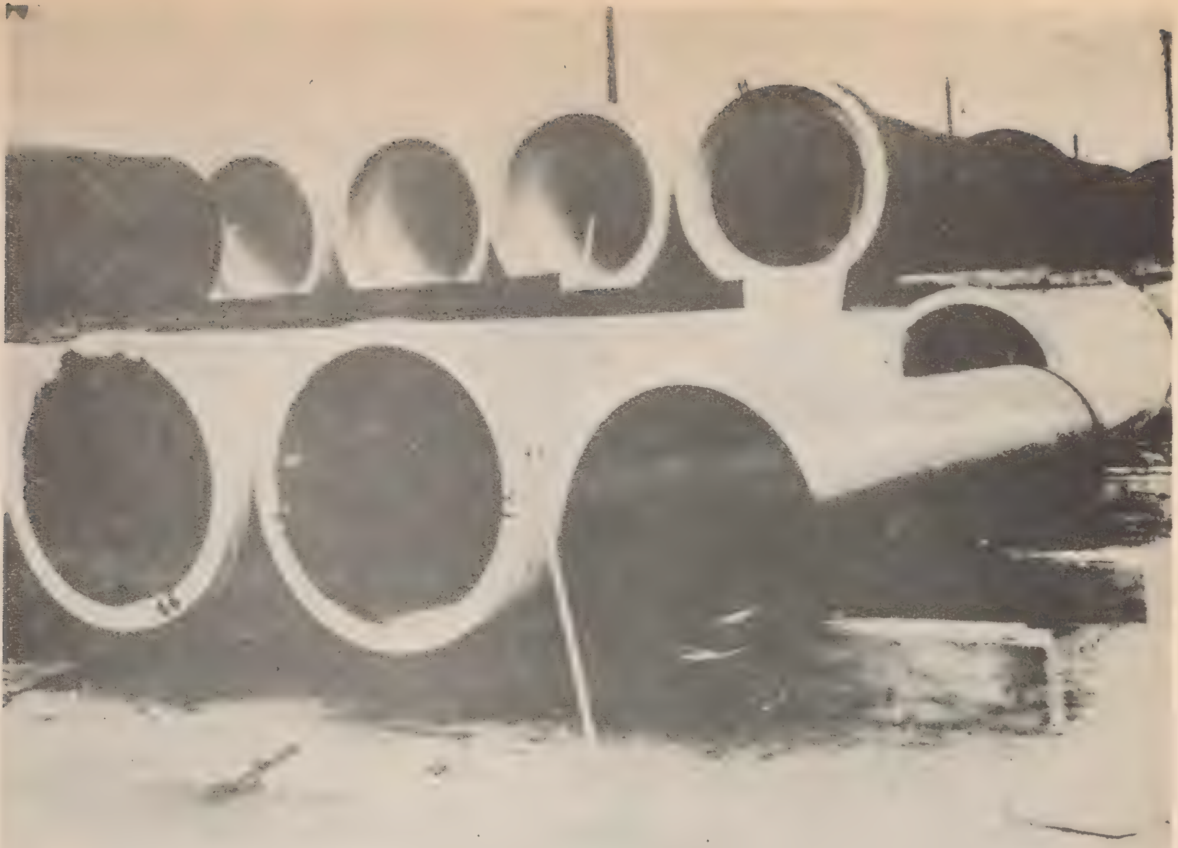
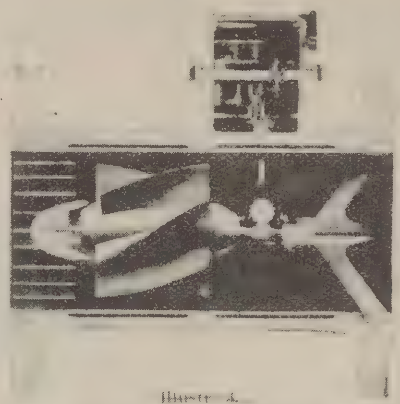
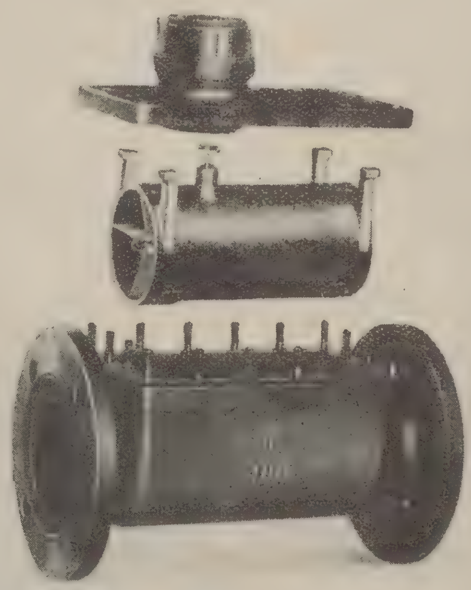


Fig. A-21-e, a type of reinforced concrete low pressure pipe used in Leipzig.

Fig. A-21-f, new steel pipe being installed in bomb crater to replace destroyed pipe.



Illustr. 3.
Type WH Diameter 2 to 8 inch



Illustr. 4.
Type WmII Diameter 4 to 8 inch.

Fig. A-21-g, a type of in-the-line water meter used in Germany.

REPORT

ON

WATER SUPPLY, SEWAGE, and INDUSTRIAL WASTE TREATMENT

IN GERMANY

SECTION B

SEWAGE TREATMENT

INDEX

SECTION B

SEWAGE TREATMENT

SECTION B

SEWAGE TREATMENT

In connection with the group's investigation of sewage treatment, the following targets were visited:

(a) CONSULTING OR DESIGNING ENGINEERS

Target No.	
B-1	Dr. K. Imhoff - Shondorf am Amersee
B-2	Dr. W. Breitung - Wiesbaden
B-3	Dr. W. Merkle - Wiesbaden
B-4	Dr. W. Sohler - Stuttgart
B-5	Dr. E. Steuer - Neustadt ad Haardt
B-6	Deutsche Abwasser-Reinungsgesellschaft - Wiesbaden

(b) RESEARCH INSTITUTES

B-7	Reichsanstalt für Wasser und Luftgüte - Berlin - Dahlem

(c) SANITARY DISTRICTS

B-8	Emscher and Lippe District - Essen
B-9	Ruhr District - Essen
B-10	Niers District - Viersen

(d) EQUIPMENT MANUFACTURERS

B-11	Passavant-Michelbach
B-12	Breuer - Höchst (near Frankfurt am Main)
B-13	Bamag-Meguin - Giessen
B-14	Machinenfabrik H. Geiger - Karlsruhe
B-15	Machinenfabrik Esslingen - Esslingen
B-16	Bopp und Reuther - Mannheim

(e) SEWAGE TREATMENT PLANTS

B-17	Leipsic	
B-18	Halle	
B-19	Hagen	Ruhr District
B-20	Essen-Rellinghausen	Ruhr District
B-21	Heiligenhaus	Ruhr District
B-22	Iserlohn	Ruhr District
B-23	Hattingen	Ruhr District

Target No.		
B-24	Essen-Nord	)
B-25	Alte-Emscher	) Emscher and Lippe District
B-26	Karnap	)
B-27	Soest	)
B-28	Frankfurt am Main	
B-29	Hildesheim	
B-30	Berlin-Stahnsdorf	
B-31	Berlin-Wassmannsdorf	
B-32	Nürnberg	
B-33	Bad Nauheim	
B-34	Munich	
B-35	Stuttgart	
B-36	Mannheim	
B-37	Tubingen	
B-38	Ludwigshafen	
B-39	Bad Soden	

Summary

Based on information gathered from these various sources the following is, in our opinion, a fair generalization of the status of sewage treatment in Germany from 1938 to the present time:

1. About 165 plants were constructed during the period. These were divided about as follows:

Municipal (includes plant additions)	50
Military	90
Miscellaneous (Institutions, industrial, housing, etc.)	25
	165

Practically all of the municipal plants were built or remodelled prior to the war. The largest new municipal installation was for the City of Posen. This list does not, of course, include many sewage farms built during this period.

2. Most of the newer plants built were for primary treatment only. Imhoff tanks were used for most of the military camp plants. Practically all of the secondary treatment plants used trickling filters, a large number of which were high rate units.

3. New plants built and projected were along conventional lines as used in the U.S. In the larger cities, the sewers are normally combined, storm water flows up to 3-5 times the average dry weather flow being handled in the plant settling tanks. The following summarizes unit production practice:

(a) Screening: Rotary screens for storm water overflow are used to a limited extent. Bar screens are generally cleaned by mechanical means. There is an increased trend toward screenings grinding.

(b) Grit Chambers: Except in a few very large plants grit is settled out in plain longitudinal channels, the grit being removed by hand or by means of bucket elevators or grab buckets.

(d) Settling Tanks: Clarification tanks are round or rectangular. Both designs are characterized to a great extent by complicated inlet and outlet designs, and by the use of very large and deep sludge hoppers.

Mieder type mechanisms are generally used for cleaning the rectangular tanks. For round units, both pitched blade and spiral scrapers are used. For secondary settling deep Dortmund tanks find considerable favor.

(d) Aeration Tanks: Aeration units are usually of the spiral flow diffused air type. Imhoff type paddles formerly used to a considerable extent are now in disfavor. Straight mechanical aerators are practically non-existent. During the war, in order to save power, most aeration units were taken out of service.

(e) Trickling Filters: Rotary distributors are generally used for filter beds except in small military installations where fixed trough grids were used.

Filter media beds are generally 3 to 4 meters in depth, the media being graded in size. Pre-cast concrete underdrains are used in preference to ceramic tiles.

High rate filters are coming into favor. Enclosed filters are preferred in the Emscher and Ruhr Districts (Prüss influence).

(f) Contact Aerators: This secondary ~~treatment~~ device has completely disappeared in Germany, being superseded by the activated sludge process or by trickling filters.

(g) Digesters: Practically all digesters are heated and provided with gas collection facilities. Rotating heating coils for better heat transmission are common. External sludge preheaters are also used to some extent. Internal heating coils now favored are of a type that can be removed for cleaning without interfering with tank operation. Stirring or sludge distribution devices are widely used, care being taken not to disturb bottom digested sludge. Stage digestion is used to a considerable extent.

Digestion tanks are generally built with conical tops as well as bottoms in order to reduce the surface area of possible scum layers and so make it easier to mechanically break down scum. Earth banking of digesters is rare, cork or air cell insulation being used to conserve heat.

(h) Gas Utilization: The compression and utilization of methane gas for driving automobiles is almost universally used in Germany and has been developed to a high degree. One gathers the impression that the sole purpose of operating sewage treatment plants throughout the war was expressly for the purpose of such gas collection and utilization. Rather than use the digester gas for sludge heating or for power generation at the sewage plant, coal and electrical energy have been used for these purposes in order to make a maximum amount of gas available as automobile fuel.

(i) Sludge Drying: Open sand beds are generally used. In a few projected large plants mechanized dewatering of sludge on vacuum filters is contemplated.

(j) Chlorination: During the war chloraination was not practiced at any plant due to the lack of chlorine gas. Normally the use of chlorine is rare.

(k) Fish Ponds: Fish ponds, although at present used to a considerable extent for effluent treatment, are falling into disuse. It is questionable if their use will be contemplated in future designs.

(l) Sewage Farms: This method of sewage treatment was favored during the war years, but is regarded as a temporary makeshift and will undoubtedly be discarded in favor of more orthodox sewage treatment methods.

(m) Chemical Treatment: The use of chemicals for sewage treatment is rare in Germany due to high chemical costs. The Niersverband process may have some promise for very strong sewage.

(n) General: In general, concrete work at German sewage plants is very complicated. Mechanical equipment is likewise complex and cumbersome.

4. Sewage plants in general were poorly maintained during the war due chiefly to the lack of personnel and materials. A large number of plants suffered severe bomb damage. Due to bomb damage to sewers most plants were operating at greatly reduced flow resulting in septic conditions in primary plant systems.

5. Few plant records were available and plant operators rarely were informed regarding flow data, plant performance or analytical results. This was especially true of individual plant operators in sanitary districts. Good laboratory facilities were generally provided at all plants except those in sanitary districts.

6. No new processes or major items of equipment for use in sewage treatment were developed in Germany during the period 1938-45.

7. Items of special interest to U.S. engineers, etc., are:

(a) The Niersverband chemical-biological process for treating strong sewages and reducing coagulant requirements (Target B-10).

(b) The Soest flowsheet involving the aeration of trickling filter effluent to improve final effluent quality (Target B-27).

(c) Enclosed trickling filters to reduce fly and odor nuisance (Targets B-21, B-22, and B-27).

(d) Brick surfaced sludge beds to facilitate sludge removal and reduce sand losses (Target B-32).

(e) Gas scrubbing and compression equipment for making gas available as an automobile fuel (Target B-15).

(f) Digester sludge distributing mechanisms for improving sludge digestion (Targets B-11, B-32).

(g) Extensive use of pneumatic ejectors for raw sludge pumping (Targets B-12, B-28).

(h) Disappearance of contact filters from Germany; last unit at Hattingen replaced by activated sludge (Target B-23).

(i) The use of rotary screens to treat storm water (Targets B-11, B-14).

(j) The use of highly nitrified partial flow to "sweeten up" septic raw sewage (Target B-1).

(k) Gas generation from farm wastes (Target B-1).

(l) Prüss settling tank design with special reference to the effluent take-off (Target B-25).

(m) The use of a trickling filter for treating digester overflow liquor (Target B-29).

(n) Methods of chemical analyses of sewage and sludge (Target B-7).

(o) Tests on high rate filter process (Target B-7).

(p) Filter underdrain design (Target B-11).

(q) The removal of CO_2 from digester gas, and the neutralization of highly alkaline trade waste by passing the digester gas through the waste (Target B-35).

(r) The use of rotating heating coils for heating digester contents (Targets B-23, B-35).

DETAILED TARGET REPORTS

TARGET NO. B-1

Name: Dr. Ing. K. Imhoff

Location: Schondorf am Amersee (near Munich)

Date Visited: (1) August 2, (2) August 3, 1945

Persons Interviewed: Dr. Imhoff

Interviewed By: (1) Lt. Col. Gilbert, Major Tatlock
(2) Fischer, Gorman, Sheridan

INFORMATION OBTAINED

Dr. Imhoff stated that there had been no new developments in sewage treatment in Germany during the war years.

In a design for an activated sludge plant to treat the sewage from a population of 1,300,000 in the City of Berlin, Imhoff contemplated the use of three separate aeration plants. In one, the treatment was to be carried to a high degree of nitrification and the final effluent recirculated to the raw sewage entering all three units. In this way, it was thought that the septic sewage could be made more amenable to treatment, and the air consumption possibly reduced. Odors due to the raw sewage would also be minimized.

During the past year, Dr. Imhoff has given considerable time to a study of gas production from organic farm wastes such as barnyard manure, etc. He believes that there will be a considerable field for the digestion of such material in Germany and possibly some other countries for the production and compression of the gas for automobile use during the post-war years.

In carrying out this scheme, the stable manure would be diluted to 90% moisture and introduced into a digester equipped with a stirring mechanism. For a small farmhouse with only four cows the capacity of the digester would be 15 cu. meters. The estimated daily gas production would be 9 cu. meters. With more straw or other waste added

this production could be readily increased to 15 cu. meters/day. In addition to the digester, an equalizing gas holder or gas bag having a capacity of 9-15 cu. meters would be required.

For a large South German farmers' village a daily gas production of 2400 cu. meters containing 1440 cu. meters of methane would be produced, corresponding to 1730 liters of gasoline/day. Installation costs of such a plant would be 340,000 RM. The annual power costs would be 29,000 RM. Supernatant liquor and residual digested sludge would be used as fertilizer. Floating matter would be skimmed off daily and used in the same manner.

At the present price of gasoline in Germany (40 Pf per liter) gas production from manures would be commercially attractive as methane gas could be provided at an over-all cost of 35 Pf per cu. meter. In countries such as the U.S., where there is an abundance of natural oil, it is questionable whether the scheme would be attractive.

GENERAL OBSERVATIONS

Dr. Imhoff's statements regarding the progress of sewage treatment in Germany during the war years confirms our views as gathered from discussion with other German sanitary engineers and visits to numerous representative plants.

The belief that individual or collective farm digesters will be built in Germany is of interest. The broad idea is not new and was first suggested in the U.S., by Buswell some years ago. However, it made little or no headway. With the background of German experience in the use of gas for automobiles, there is a possibility that the scheme will gain greater headway in Germany. The question of financing such works is, however, a problem.

ITEMS OF INTEREST

Complete nitrification and recirculation of part of a sewage effluent may be of interest to U.S. engineers.

NEW PROCESSES OR EQUIPMENT

It is not believed that either of the two ideas proposed by Imhoff are new. Oxidized and nitrified effluents have been returned in the past for their beneficial effect (Biofilter Process). Activated sludge effluent has also been recycled. Buswell has previously suggested gas production of gas from barnyard wastes.

TARGET NO. B-2

Name:	Dr. Ing. W. Breitung and Company
Location:	2 Neurotal Strasse - Wiesbaden
Date Visited:	July 17, 1945
Persons Interviewed:	Dr. Ing W. Breitung
Interviewed By:	Fischer, Lt. Col. Gilbert, Sheridan

INFORMATION OBTAINED

Dr. Breitung is a private consulting engineer who during the war has designed for the Organization Todt about 25 sewage treatments for army installations ranging in size from 50 persons to 1500 persons. In addition, he designed about 35 other military plants. Breitung knows the actual location of only a few of these plants as he furnished the plans only.

Drawings of sewage treatment plants were secured from Dr. Breitung to illustrate present design practice in Germany. These are as follows:

Figure B-2-a (Dwg. No.3525). Plants for 50 and 150 persons. Imhoff primary treatment.

Figure B-2-b (Dwg. No.3521). Plant for 300 persons. Imhoff primary and final settling tanks and trickling filters with horizontal troughs for distribution of the sewage.

Figure B-2-c (Dwg. No.3525a). Plant for 600 persons; same units as in Drawing No.3527.

Fibure B-2-d (Dwg. No.3423). Plant for 1200 persons. Covered Imhoff tanks for primary treatment.

In the design of the plant for 600 persons (Figure B-2-c), the following figures were used:

Flow - 150 liters/capita/day or 39.36 gals/capita/day.

Total daily flow - 90 cbm/day or 23,616 gals/day.

Maximum hourly flow and design flow - 15 cbm (1/6 of total daily) or 3936 gals/hour

The design rate, therefore, is 157.44 gals/capita day.

Primary Settling Imhoff Tank: Settling capacity 28 cbm or 7347 gals., or 1.86 hours detention on maximum hourly flow.

Sludge capacity 38 cbm, 1340 cu. ft. (based on 60 liters per capita or 2.1 cu. ft./capita).

Trickling Filter: Capacity 45 cbm or 58.95 cu. yds. = 1/2 cbm stone per/cbm of sewage, or 6.6 M. gals., per acre for 10 foot deep filter based on the average flow, or 26.4 M. gals/acre on the maximum hourly flow.

Final Settling Imhoff Tank: Settling capacity 10 cbm or 2624 gals., or .66 hours detention based on the maximum hourly flow.

Sludge capacity 15 cbm, 530 cu. ft. (based on 25 liters per capita or .88 cu. ft./capita).

GENERAL OBSERVATIONS

(a) The Imhoff tanks are novel in that a separate scum compartment is constructed at the influent end of the tank.

(b) Fixed distribution grids are used on the trickling filters.

(c) Filter bottoms are constructed of approximately 2 inch thick precast concrete slabs with 1-1/2 inch diameter holes, and provision is made for the introduction of air by natural up-draft.

(d) All plants were designed along similar lines with certain minor variations.

(e) Recirculation of the sewage or the sludge or the introduction of a forced draft was not used.

(f) Due to the fact the plants are designed on the maximum hourly flow (1/6 total daily) they are over designed, based on American practice.

ITEMS OF INTEREST

The design features of these small plants should be of interest to U.S., sanitary engineers.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-3

<u>Name</u>: Dr.Engineer Wilhelm Merkel,consult.engr.

<u>Location</u>: Danziger Str 58 - Wiesbaden

<u>Date Visited</u>: July 19, 1945

<u>Persons Interviewed</u>: Dr. Ing. W. Merkel

<u>Interviewed By</u>: Dr. Fischer, Lt. Col. Gilbert

INFORMATION OBTAINED

Dr. Merkel was formerly chief engineer of Buro f. Stadehygiene und Wasserbau. His office was bombed out and practically all his drawings and records were destroyed.

Merkel has made designs for a few municipal sewage treatment and for some waste treatment plants. Several of the latter have been built. He has also designed several sewage treatment plants which have been built for army camps. These consisted of standard design for small Imhoff tanks and trickling filters.

Merkel used the following design features in plans prepared for a large plant for the City of Berlin:

(a) Mechanical screens.

(b) Plain conical bottom settling tanks as he believed mechanical collectors are liable to give trouble due to ice formation in primary as well as secondary units.

(c) Rotating heating coils which serve as scum breakers and heat distributors in digestion tanks.

(d) Two stage sludge digestion.

(e) Supernatant liquor pumped to the hoppers of the digestion tanks to loosen the sludge.

GENERAL OBSERVATIONS

Few plants have been designed by Dr. Merkel for the sewage treatment field for the past seven years. The interview indicates that the construction of municipal sewage

treatment plants was practically at a standstill during the war. The main construction done was waste treatment for war industries and sewage treatment for army camps or other government installations.

ITEMS OF INTEREST

None.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-4

Name: Dr. William Sohler

Location: Stuttgart

Date Visited: July 27, 1945

Persons Interviewed: Dr. Sohler

Interviewed By: Lt.Col.Gilbert, Lt.Pfreimer, Dr.Sheridan

INFORMATION OBTAINED

William Sohler, City Engineer of Sewers in Stuttgart, and highly regarded consultant on sanitary engineering, is the author of numerous publications. He discussed at length phases of sewage treatment and byproduct development.

The Stuttgart Treatment Plant has been the laboratory for various experiments which he has directed. Among these are:

(a) Careful screening, washing and grading sand and grit, contained in the combined sewer flow from three drainage sheds. An absence in this area of much needed sand for highway construction and maintenance justifies this process in a separate plant.

(b) The use of a combined skimmer and sludge remover which moves forward at a rate of 30 cm per second to remove scum, drops shovel and returns at a rate of from 5 to 10 cm per sec., with lowered sludge shovel.

Various types of settling tanks have been constructed and differing detentions used to make comparisons of effectiveness.

(c) Sludge, partially digested, 85% water, is mixed with peat in proportions of four of the latter to one of the former for fertilizer. Engineer Sohler claims that the product is better than that resulting from use of completely digested sludge.

(d) Flat roofed, conical bottom digestion tanks with vertical rotating pipe heating apparatus that maintains constant temperatures throughout the sludge and also prevents scum formation.

(e) Gas from the digestion tanks is passed tannery waste from one drainage area. By so doing the quality of the gas is improved through removal of CO_2. The pH value of the waste is reduced from 10 to 7 and digestion is aided.

(f) Slow and rapid filters have been compared under various conditions for comparative purposes.

(g) Sludge is to be mixed with raw garbage and through aerobic processing is to be used for fertilizer.

GENERAL OBSERVATIONS

The various processes and methods above noted all appear to be practical and justified under circumstances similar to those in Stuttgart.

ITEMS OF INTEREST

The items described have been selected from a very comprehensive plant because they appeared to be of general interest.

NEW PROCESSES OR EQUIPMENT

No new theories or unique processes.

TARGET NO. B-5

Name: Dr. E. Steuer

Location: Neustadt a.d. Haardt, Germany

Date Visited: July 25, 1945

Person Interviewed: Dr.Steuer, Supt., City Sewer Dept.

Interviewed By: Lt.Col.Gilbert, Lt.Pfreimer, Dr.Sheridan

INFORMATION OBTAINED

Dr. Steuer is the inventor of the Neustadt tank which is used for the removal by settling of solids from sewage or other liquids. Dr. Steuer is a chemist who designs sewage and industrial waste treatment works. He also operates the sewage plant at Neustadt.

The first Neustadt tank was built in 1910. A number of these tanks have been built throughout Germany, but have never become very popular.

Figure B-5-a illustrates the present design of these tanks, the two principal features of which are:

(a) The influent channel discharges the sewage in a direction toward the influent end of the tank and thereby causes a change of direction of the flow and an initial velocity toward the effluent end of zero.

(b) The sludge is withdrawn after a concrete slab is lowered into the hopper bottom of the tank so that a narrow sludge conduit is formed. When the sludge discharge valve is opened at one end of the tank, a small carriage (p) is forced along this conduit by hydrostatic head pushing the sludge before it. This method of sludge withdrawal results in a moisture content of 90%. The sludge is withdrawn one or two times a day. The carriage is returned to its initial position by a hand winch after it has reached the sludge hopper and the sludge has been withdrawn.

The Neustadt tanks are usually constructed 25 to 28 meters long, 4 to 4-1/2 meters wide, and 4 meters deep. For sewage the design detention period is 1 to 2 hours.

Dr. Steuer in the design of his plants uses a very simple digestion tank as shown in Figure B-5-b. The features of this tank are:

(a) Sloping roof with small horizontal section which reduces the possibility of cracks and gas leakage.

(b) Water heating coils installed only on the bottom of the tank to induce natural mixing of the sludge.

(c) Sludge pumped to the tank through a sprayer which distributes the sludge over the surface and breaks up the scum.

(d) A floating rod provided to indicate the sludge level in the tank.

(e) No provision is made for the withdrawal of supernatant liquor as Steuer claims it is better to place all the digester contents on the sandbeds in small installations.

Steur has also used a rock filter 2 meters square by 2 meters deep for the supernatant liquor from 5,000 people. The flow to these filters is distributed by means of a horizontal pipe system. The discharge from the filter can be returned to the primary settling tanks or direct to the river. No chemical or biological analysis of the filter discharge is available to indicate the efficiency of this type of treatment of supernatant liquor.

GENERAL OBSERVATIONS

The Neustadt tank should produce a high removal of settable solids and a low moisture content sludge. However, it is not believed that these tanks will be adopted in America, due to their complicated construction and to operational difficulties.

The digestion tank as described above is interesting. However, all of its features are known to American engineers.

The treatment of supernatant liquor on trickling filters might be worthy of American consideration.

ITEMS OF INTEREST

The digester design and the supernatant liquor treatment schemes may be of interest to U.S., engineers.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-6

Name:	Deutsche Abwasser-Reinigungs-Gesellschaft m.b.H. (Oms-Haus)
Location:	Wiesbaden, Germany
Date Visited:	July 17 and 28, 1945
Persons Interviewed:	Chief Engineer Büllman, Engineer Bendler
Interviewed By:	Dr. Fischer, Lt. Col. Gilbert, Maj. Tatlock, Lt. Pfreimer

INFORMATION OBTAINED

The Oms-Haus is a firm of engineers which design industrial waste treatment and municipal sewage treatment plants. After the plants are designed, the mechanical equipment is purchased by Oms-Haus and a contractor employed to do the construction and erection work.

A list of the treatment works which have been designed and built by this company since 1938, is attached so that the type and number of treatment plants that have been built by them in Germany may be evaluated.

In July 1943, the Oms-Haus designed and started construction on a sewage treatment plant for Posen. This plant was 80% completed but it is believed to have been ruined by bombing.

In order to determine the present design practice of this company the following information relative to the design of the Posen plant was obtained:

(a) Like most plants in Germany, the Posen plant was designed for the dry weather flow, this flow being 900 L/second for a population of 300,000 people. The storm flow will reach a peak of 2300 L/second, but all over the dry weather flow will be by-passed direct to the river.

(b) Two mechanically cleaned coarse bar screens with 40 mm. openings were provided. The screens were of the "Passavant" type and were equipped with "Passavant" screenings

grinders. Due to the close clearance construction of these grinders the screenings must be fed by hand from the screen. The screens, however, are automatic, being operated by a float differential head control.

(c) Two "Geiger" tangential flow grit chambers were installed to remove the grit from the sewage. These chambers were designed for a detention period of 2 to 3 minutes, the grit being agitated by air for washing in the chamber and then elevated by air to the storage tank. The storage tank was provided with a 15 mm mesh screen over the top so that all particles over this size could be removed.

(d) The three primary settling tanks are designed for a one-hour detention period. Oms-Haus usually designs for two hours detention but the war caused this reduction in the detention period in order to conserve construction materials. It is felt by the engineers that this one-hour detention period will remove the majority of the large particles of the sewage. One Passavant sludge collector of the Mieder type was to be installed with a transfer car to move the collector from one tank to the other. The collector was to operate at a speed of 1 meter per minute while collecting the sludge and scum to the influent end of the tank, and 4 meters per minute while returning to the effluent end of the tank.

(e) The sludge and scum will be discharged to the sludge digesters by means of air pressure. The use of sludge pumps is not standard practice in Germany. The sludge and scum usually flow by hydrostatic head from the settling tanks to a steel pressure tank. When the tank is nearly full, compressed air is admitted and the sludge is ejected to a receiving box on top of the digesters where any air is released and from where it flows by gravity to the digesters.

(f) Four digesters are provided having a total design capacity of 14 liters per person. Normal design would call for 30 to 40 liters per person, but the engineers had to design so that the maximum amount of gas could be obtained for the least use of construction materials.

The tanks are heated with 50°C water passing through coils and are maintained at a temperature of 25 to 27°C.

The supernatant liquor is returned direct to the primary settling tanks.

The sludge and scum are admitted to a digestion tank through a Passavant mechanism which consists of a rotating pipe with two hollow arms. The mechanism is rotated by a motor so that the sludge is thrown from the arms over the surface of the scum in the tank and with such force that the scum is broken up.

It is expected that 18 to 20 liters of gas per day will be received from each person contributing to the plant. Approximately one day's gas storage should be provided or about 5000 cbm, but only a 1000 cbm gas holder was provided to save steel.

The sewage gas usually contains 6400 calories per cbm while the artificial gas contains only 4800 calories per cbm. Therefore, the sewage gas is not burned to heat the digesters but is compressed for automobile fuel, one cbm of gas producing one cubic liter of fuel. The gas is cleaned by passing through iron ore which is regenerated by air drying. The hot water for the digestion tank is heated with coke.

(g) The partially digested sludge is discharged to sludge drying beds which are designed for a capacity of 20 persons per sq. meter. The sand bed consists of 30 cm of coarse sand topped with 5 cm of fine sand and provided with a 100 mm diameter main drain and with 80 mm diameter laterals. The fine sand is paved with 6 cm thick building bricks which are laid with 2 cm openings. Usual practice is not to use the brick paving on sludge beds but since sand is valuable and scarce in this area it was used as a means to conserve the sand

GENERAL OBSERVATIONS

The Posen sewage treatment plant was one of the few municipal plants constructed in Germany during the war. The plant was built with the primary objective of obtaining gas for use in automobiles at the least possible cost. From the standpoint of sewage treatment it was greatly under-designed not only by American but also German standards.

The plant was designed using the most modern German equipment, which is described in target reports on the several manufacturers.

ITEMS OF INTEREST

Interesting items of equipment are covered in other target reports.

NEW PROCESSES OR EQUIPMENT

None.

DEUTSCHE ABWASSER-REINIGUNGS GESELLSCHAFT m.b.H. PLANTS

A. Industrial Waste Treatment Plants

Hoesch-Köln-Neuessen A.-G., Dortmund
Neutralization tanks
Reichswerke für Erzebergbau und Eisenhütten, Braunschweig
Steel mill plant
Bahnmeisterei I, Uelzen
2 oil separators for Lokschuppen
Deutsche Reichsbahn, Bingerbrück
Clarification and oil removal
Bahnmeisterei I, Homburg/Saar
Oil separators 2500 mm Ø
Hoesch A.-G., Dortmund
Clarification tank for steel mill works
Marinebauamt Sanderbusch
Clarification tank for Marine Hospital
Dortmund-Hoerder Hüttenverein, Dortmund
Cooling water
Bahnmeisterei Frankfurt/a.M.-Nied
Oil separators 2500 mm Ø for R.A.W. Nied
Klöckner-Werke A.-G., Troisdorf
Clarification plant for blast furnace wash water
Hoesch A.-G., Dortmund
Neutralization plant
Reichswerke Braunschweig
2 Thickeners for blast furnace wash water
Deutsche Reichsbahn, Lüneburg
Oil separators
Saargruben A.-B., Saarbrücken
Coke clarification plant
Deutsche Reichsbahn, Marktredwitz/Bay
Oil separator
Deutsche Reichsbahn, St. Wendel
Oil separator
Henschel G.m.b.H., Kassel
Oil removal
Deutsche Reichsbahn, Wetzlar
Oil removal
Deutsche Reichsbahn, Hamburg-Wilhelmsburg
Oil removal
Deutsche Reichsbahn, Solingen
Oil removal
Deutsche Bergwerks- und Hüttenbauges., Braunschweig
Sludge filter plant

B. Domestic Sewage Plants

Oberbürgermeister Offenburg/Baden
Kreisbauamt Bitburg
Hochbauverwaltung im Ministerium d. Finanzen, Oldenburg i.O.
Wohnungs A.-G. der Reichswerke Braunschweig
Schulungsburg Vogelsang/Eifel
Stadt Boppard
Deutsche Reichsbahn, Hanau
Stadt Rheine
Reichswerke Watenstedt
Luftwaffe Hanau
Stadt Wetzlar
Oberbürgermeister Wilhelmshaven
Henschel Flugmotorenbau G.m.b.H., Kassel
Prof. Ebhardt, Berlin - For Herr Lichtenau
Fa. Tibet, München
Dipl.-Ing. M. Rahde, Hannover for Dorworden
"Weser" Flugzeugbau G.m.b.H., Bremen
Kieler Werkswohnungen G.m.b.H., Kiel
Deutsche Reichsbahn, München
E. Müller & Co., Bremen - For Barracks Kiel-Neumüllen
Marine Wilhelmshaven Barracks
Luftwaffe Hamburg-Sinstorf
Luftwaffe Münster-Dethlingen
Kreisbauamt Kassel
B.M.W. München
Kreisbauamt Kassel
Bürgermeister Eschwege
Heeresbauamt Bitsch
Prof. Clemens Klotz, Köln for Vogelsang/Eifel
Marine Flensburg-Mürwik
Maschinenfabrik A.-G., Bitschweiler/Elsass
Prof. E. Neufert, Berlin - List, Rhenau/Elsass
Luftwaffe Vechta
Bauleitung Kiel
Kipp & Elfers, Wesermünde for Drangstedt
Marine Wilhelmshaven
Deutsche Reichsbahn, Fulda
Deutsche Reichsbahn, München
Henschel Flugmotorenbau G.m.b.H., Kassel
Deutsche Reichsbahn, Oldenburg
Ingenieurbüro C. Ricken, Hamburg-Harburg for Blankenburg/Oldenburg
Bürgermeister Unterlüss/Hann
Architekt W. Fricke, Hannover for Renteln
Zeppelin-Reederei, Frankfurt/a.M.

Oberste Bauleitung Köln
Landesversicherungsanstalt Baden, Strassburg
Architekt E. Lienhard, Waldshut/Baden for
Lungenheilstätte Jestetten
Baubevollmächtigter Köln
Architekt E. Gondram, Köln for Bergisch Born
Architekt Fr. Kurz, Frankfurt/a.M.
Bleidenstadt/b. Wiesbaden
Kurbelwellenwerk G.m.b.H., Glinde/b. Hamburg
Stadtbaubüro Fallersleben, Stadt des
K.D.F.-Wagens
Bauleitung Dogger, Hersbruck/b. Nbg.

TARGET NO. B-7

Name: Reichsanstalt für Wasser und Luftgüte

Location: Berlin-Dahlem

Date Visited: July 28, 1945

Persons Interviewed: Heins, Meinck, Schmidt, Tiegs

Interviewed By: Fischer, Gorman

INFORMATION OBTAINED

The Reichsanstalt was formerly known as the Landestalt für Wasser, Boden und Lufthygiene. It is a research institute supported by the German government and carries out investigational studies on water, sewage and air.

The above named men stated that during the war no new processes or items of equipment for use in sewage treatment were developed.

Work done at the Reichsanstalt during the war has been reported as in the past in the "kleine Mitteilungen". Copies of these reports from 1939-43 were obtained. Items of special interest covered in these reports are as follows:

(a) The chemical testing of sewage with special reference to sludge and receiving water analyses (Aug. 1941, 191 pages).

(b) English-German and German-English dictionary of water and sewage terms (Feb. 1943, 71 pages).

(c) Report on status of sewage treatment in England (Jan.-May 1939, 70 pages).

(d) A description of the new sewage test plant of the Institute at Berlin Stahnsdorf (Jan.-March 1940, 14 pages).

(e) Investigation of U.S. designs of high rate filters, (Halvorson and Jenks), (Jan.-March 1940, 15 pages).

(f) Investigations of a two-stage trickling filter plant (Kremer Co.),(Jan.-Mar. 1940, 4 pages).

(g) Report on biology of trickling filters at Berlin Stahnsdorf test plant (July-Sept.1940, 5 pages and Oct.-Dec. 1941, 8 pages).

Results of studies of high rate filters led to the conclusions that the use of media greater in size than 4-8 cm is not suitable, that artificial aeration is of no advantage, and that effluent recirculation is of great advantage.

Work done at the Institute on trade waste is discussed in a separate section of this report.

ITEMS OF INTEREST

The references in the "Kleine Mitterlungen" dealing with sewage research, methods of analysis, etc., should all be of interest to U.S., engineers and research workers. The copies of all these journals are being transmitted to the U.S., so that interested parties may examine them in detail.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-8

Name: Emscher and Lippe Districts

Location: Essen

Dates Visited: June 28 and 29, 1945

Persons Interviewed: Dr. Ramshorn, Dir., Dr. Húsmann, Chief Chemist, Mr. Wiegmann, engineer in charge of sewage treatment

Interviewed By: Fischer, Gorman, Sheridan

INFORMATION OBTAINED

We were informed by the above named officials that during the war no new construction of sewage treatment plants had been carried out in this district, and that expenditures for plant maintenance had been held to a minimum.

Location of all sewage treatment and phenol recovery plants operated in both districts are shown in Figures B-8-a and B-8-b.

Of the newer installations built or altered just prior to the war, those at Soest, Hamm and Alte-Emscher were said to be the most interesting from the standpoint of new equipment. The Essen-Nord and Karnap plants were also mentioned as being of interest because of bomb damage. All of these plants except Hamm were visited and are reported on separately.

The plant at Hamm is similar to that at Alte-Emscher and consists of a Prüss type clarifier preceded by a plain bar screen. It was designed to treat 80,000 cu. meters of sewage per day from a population of 50,000.

Operation of the phenol recovery plants was also discussed and a typical plant visited. This is also reported on separately.

Research work carried out by the district involved studies of methods of treating phenolic liquors; physical, chemical and biological investigations of high-rate filters; and investigations of land treatment and fertilizer values of sewage.

GENERAL OBSERVATIONS

The main office of this district was severely damaged by bombs. All the laboratory facilities were destroyed. It was stated that most of the district records, reports, etc., were also destroyed by bombing or fire resulting from air raids.

ITEMS OF INTEREST

Work on phenol recovery and on high rate filters; also various plant structures as reported on in separate targets.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-9

Name:	Ruhr District
Location:	Essen
Dates Visited:	June 28, 30, July 3, 1945
Persons Interviewed:	Fries, district engineer; Sierp, chief chemist; Bucksteeg, asst.chief chemist
Interviewed By:	Fischer, Lt.Col.Gilbert, Gorman, Sheridan

INFORMATION OBTAINED

The main office of the Ruhr District located in Essen was destroyed by bombs, and the Director of the District, Dr. Pruss had moved his office to his home in Olpe about 60 miles southeast of Essen. It was not possible to contact Dr. Pruss so information regarding the work of the District was obtained from Mr. Fries, and Drs. Sierp and Bucksteeg.

As in the case of the Emscher and Lippe Districts, no new construction of sewage plants was carried out in the Ruhr District during the war. Plant maintenance was also held to a minimum as was evidenced by visits to typical installations.

Plants visited were those at Essen-Rullinghausen (where the District laboratories were located), Hagen, Heiligenhaus, Iserlohn, and Hättingen. Details regarding these plants are contained in separate reports.

The treatment of industrial wastes was discussed with Dr. Sierp who pointed out that in general all work on phenol wastes for both the Emscher and the Ruhr Districts is carried out by the former. On the other hand, all work on metallic waste waters such as pickling liquors, etc., is carried out by the latter.

The treatment of these industrial wastes is discussed in detail in another section of this report.

Development work carried out by the Ruhr District during the war years has been chiefly on metal waste waters and on high rate filters. According to Dr. Sierp, practically all the records regarding this work were destroyed by fire.

ITEMS OF INTEREST

Work on pickling liquors. See "Industrial Waste" Section.

NEW PROCESSES OR EQUIPMENT

See "Industrial Waste" Section.

TARGET NO. B-10

Name:	Niers District
Location:	Viersen
Date Visited:	July 1, 1945
Person Interviewed:	Dr. Ing. Jung
Interviewed By:	Fischer, Gorman, Sheridan

INFORMATION OBTAINED

The Niers District covers an area of 1400 sq. meters and serves a population of approximately 480,000. It is located along the Niers River between the Rhine River and the Dutch border.

Existing sewage treatment plants taken over when the district was organized are as follows:

Plant	Type
Rheydt	Plain settling, concrete tanks
München-Gladback	" " " "
Willich	" " earth tanks
Viersen	" " " "
Süchteln-Johannistal	Settling and contact beds
Süchteln-Süd	Plain settling, earth tanks
Süchteln-Nord (Paper Mill)	Percolation tanks
Girmes, Oedt (Dye Works)	Plain settling, concrete tanks
Pluschweberei Grefrath	" " " "
St. Tönis	Imhoff tanks
Aldekerk	Plain settling, earth tanks
Nienkerk	Percolation tanks
Kevelaer	Plain settling, earth tanks
Dülken	" " " "
Niedick	" " concrete tanks

Plants built after the district was organized include:

(1) Hüls: Separate digestion plant for 6600 population. Includes two-hour settling in Mieder type clarifier. Digester capacity 430 cu. meters (See Figure B-10-a).

(2) Straelen: Imhoff tanks.

(3) Geldern: Imhoff tank, trickling filter plant for 7000 population. Includes two Imhoff tanks, four filters with a total media volume of 150 cu. m., and final Dortmund tanks (See Figure B-10-b).

(4) Kempen: Separate digestion, activated sludge plant for 16,500 population. Includes Kramer primary settling tank, aeration tank, final Dortmund tanks, digester and 40 HP gas engine (See Figure B-10-c).

(5) Gruppenklaranlagel: The main clarification plant of the Niers District or the Niersverband, known as "Gruppenklaranlage No.1", is essentially a three-stage plant involving presedimentation, chemical precipitation with iron salts, and activated sludge treatment, a method of treatment adopted because of the large proportion of industrial wastes from tanneries, paper mills, diaries, etc., present in the incoming sewage. Figures B-10-d to B-10-j inc., show some features of this installation.

The plant was designed to serve a connected population of 200,000, plus an industrial load equivalent to 600,000 people. The normal prewar flow was 50,000 cu. m./day of which 20,000 cu.m., was domestic and 30,000 cu.m./day industrial.

According to Dr. Jung, carbonation of the sewage after screening and grit removal lowers the pH value of the sewage from 8.0-9.0 down to 6.0. The carbonation step requires 10 minutes. After mixing with reduced sludge for 15 minutes in tanks equipped with longitudinal mixing paddles, the sewage is settled in two 40 meters diameter x 2.7 to 6.0 m. deep settling tanks equipped with Geiger spiral sludge removal mechanisms. The settled sewage is then brought into contact with iron filings in the presence of CO_2 in four tanks in which the contact time is 15 minutes. Stack gas is used as a source of CO_2. The sewage is then aerated in two steps, the first step being for 20 minutes for CO_2 removal and the second step for activation for 30 minutes in the presence of 20% returned sludge from the subsequent 2-hour settling step. It was stated that results showed that the use of CO_2 in the iron-sewage mixing step was unnecessary. Neither was the first aeration step needed. The activation stage, however, could well be increased to 60 minutes detention.

The excess iron-activated sludge from the intermediate settling tanks is pumped to a reduction tank where the iron salts are biologically reduced to the ferrous state. The detention period in the reduction tank is 3-4 hours.

Twenty percent sludge is recirculated in this unit and the material mixed by Imhoff type paddles. Seventy percent of this sludge is recycled to mixing ahead of primary settling while the remainder is sent direct to digestion.

Following intermediate settling the partially clarified sewage is again aerated for 30 minutes in the presence of final settled sludge. For good results, this aeration period should be increased to 60 minutes. The first detention period is 2 hours.

The tertiary effluent is then run to a fish pond of which there are three. One pond has an area of 17,500 sq. m. and a depth of 80 cm. The final effluent flows to the Niers River. Typical BOD results are:

Raw sewage	1400 ppm
Effluent to fish ponds	10-20 "
Effluent from fish ponds	5-10 "

For the treatment of sewage containing industrial waste at this plant, 50 mg Fe per liter of sewage were required. For strictly domestic sewage this iron consumption could be reduced to 30 mg/liter.

Sludge is digested in two units 28 meters deep having a capacity of 10,000 cu.m. The normal digestion period is 60 days. The digesters are heated by internal coils to 30°C. Sludge is pumped from the middle of these units. There are provisions for circulating sludge but this has not been done as the stirring action produced by gasification is quite vigorous. The digesters are equipped with gasometers. This construction has been found to be undesirable due to corrosion by H_2S and oxygen.

Normally the gas production is 6000 cu.m./day. At the present time it is down to 4000 cu.m./day. The gas is scrubbed to remove CO_2 after compressing to 15 atmospheres. It is then compressed to 200 atmospheres for use in driving automobiles. The purified gas contains 90-94% methane.

Digested sludge is at present dewatered in two of the fish ponds. A dewatering and sludge drying plant was under construction but never finished due to the war. Experiments had been run with centrifuges at Kempen using a Heine Bros. (Viersen) machine. This was a three product machine producing 1/3 sludge, 1/3 "dirty water", and 1/3 clean water. The "dirty water" containing considerable solids required

retreatment by returning it to the head end of the treatment plant. This was not considered good practice. If and when the sludge dewatering system is installed, it was stated that in all probability, elutriation with vacuum filters will be employed. A rotary drier has been installed for drying the sludge cake.

The total land area covered by this plant (exclusive of fish ponds) is 12,500 sq. meters. The total plant cost was 4,300,000 RM or 5.4 RM per capita equivalent population.

The loss of head thru the plant is about 3 meters. Peak power requirements are 1500 HP. This power is generated at the plant site by means of steam driven turbines directly connected to electric generators.

According to Dr. Jung, the bacterial reduction of the ferric hydroxide to the ferrous state effects a savings of 70% of the iron so that the actual iron consumption is reduced from 50 mg per liter down to 15 mg per liter.

The use of iron filings instead of an iron salt for coagulation was justified by the lower cost per kg of metallic iron for the former. It is questionable whether this condition would hold in the U.S. In any case, however, the bacterial reduction and reuse of the iron sludge may have possibilities and warrants further study for the treatment of very strong sewages.

By use of the flow sheet employed at this plant it is claimed that the treatment time is cut in about half. It is also claimed that by use of the process installation and operation costs are greatly reduced.

GENERAL OBSERVATIONS

When the writers visited this plant, only the primary settling tanks were in operation due to bomb damage to the tanks in which the settled sewage is mixed with iron filings.

The plant appeared to be complicated and experimental in nature. It was the only plant seen in Germany that may be considered novel in design.

A novel method of cleaning air diffuser plates involved rubbing off a thin surface film with stone and then cleaning with acid. Diffuser plates were not satisfactory

for CO_2 diffusion due to the large amount of dirt in the stack gas. CO_2 piping was enamel lined. The CO_2 compressors were lined with a synthetic acid resistant plastic.

ITEMS OF INTEREST

This process as a whole should be of interest to U.S. sanitary engineers. The biological method of reducing and recovering 70% of the iron used for coagulation should be of special interest.

NEW PROCESSES OR EQUIPMENT

Details of the process as outlined in this report are new although general information regarding the process has been published in the U.S. prior to the war.

TARGET NO. B-11

Name: Passavant-Werke

Location: Michelbach-Nassau

Dates Visited: July 17 and 19, 1945

Person Interviewed: Mr. Passavant, chief engineer Schramm

Interviewed By: Fischer, Lt.Col.Gilbert, Sheridan

INFORMATION OBTAINED

The Passavant Company manufactures equipment for use in various steps of sewage treatment. It also makes water intake screens.

The various types of equipment (besides slide gates, valves, etc.), made by this organization for use in the sanitary field are:

(a) Screens
  1. Centri-screen
  2. Screen - bar or water type

(b) Screenings grinder

(c) Grit chamber - grit removers

(d) Clarifiers
  1. Round
  2. Rectangular

(e) Trickling filter distributors

(f) Digester mechanisms

A list of municipal, military and industrial plants equipped by this company from 1938-44 is given as follows: (C = municipal, I = industrial, M = military).

Name		Equipment	Use
1.	Frankfurt a Main	A-1	C
2.	Dusseldorf	A-1, A-2, C	C
3.	Zwickau (Saxony) (Mulden Water District)	A-1, A-Z	C
4.	Copenhagen (denmark)	A-1	C
5.	Posen	A-2, B,D-2,E,F	C
6.	Luxemburg-Plant No.1	A-2, B,F	C
7.	Luxemburg-Plant No.2	D-2, F	C
8.	Erfurt	A-2, B	C
9.	Saarbrücken	A-2	C
10.	Roslau (near Leipsic)	A-2	C
11.	Stuttgart	A-2, B,E	C
12.	Wildflecken (near Schlüchtern)	A-2, E	C,M
13.	Kaiserlautern	A-2	C
14.	Bonn	A-2	C
15.	Backnang	A-2, D-2	C
16.	Fallersleben	A-2	C
17.	Essen-Nord (Emscher District)	A-2	C
18.	Bremen	A-2	C
19.	Hameln	A-2	C
20.	Tubingen	A-2	C
21.	Lüneberg (near Hannover)	A-2	C
22.	Viersen (Niersverband)	A-2	C
23.	Osnabruck	D-2	C
24.	Heidenheim	D-2	C
25.	Marburg-Lahn	D-2	C
26.	Siegmar-Schönau (Saxony) (Mulden Water District)	D-1	C
27.	Haacksbergen (Holland)	D-1	C
28.	Auschwitz (Upper Silesia)		C,I,]
29.	Pirmasens (Pfalz)	E	C
30.	Seelbach	E	C
31.	Pegnitz (near Nürnberg)	E	C
32.	Heiligenhaus (Ruhr District)	E	C
33.	Iserlohn (Ruhr District)	E	C
34.	Halle-Tafelwerder	A-2, B	C
35.	Zeitz (Saxony) (Mineralölbaugesellschaft)	D-2	I
36.	Brüx (Böhmen) (Mineralölbaugesellschaft)	D-2	I
37.	Blechhammer (Upper Silesia) (Mineralölbaugsellschaft)	D-2	I
38.	Siegburg (Rhine) (Rhine-Zellwolle)	D-2	I
39.	Hirschberg (Silesia) (Schlesische Zellwolle)	D-1	I
40.	Wittenberg (Brandenburg) (Kurmärkische Zellwolle)	D-1	I

Name	Equipment	~~Use~~
41. Kottbus (Sächsische Spinnstoffwerke)	D-1	I
42. Ehingen (Schwäbische Zellwolle)	D-1	I
43. Plauen (Sächische Zellwolle)	D-2	I
44. Bitterfeld (I.G.Farbenind)	D-2	I
45. Landsberg-Warthe (I.G.Farbenind)	D-2	I
46. Heydebrack (Upper Silesia) (I.G.Farbenind)	D-2	I
47. Dyhernfurt (Middle Silesia) (Luranil Baugesell)	D-2	I
48. Espenhain (near Leipsic) (Sächsiche Werke)	D-2	I
49. Zschornewitz (Saxony) (Electro-Werke)	D-2	I
50. Miltilz (near Leipsic) (Schimmel & Co.)	D-2	I
51. Herrenwald (by Marburg) (WASAG)	D-1	I
52. Baierbronn (Brügmann & Son)	D-1	I
53. Beddigen (Hannover) (Hermann Göring-Werke)	D-2	I
54. Flossenberg (Böhmen)	E	M
55. Salzgitter (near Braunschweig) (Hermann Göring-Werke)	A-1, E	I
56. Hottengrund (near Berlin)	E	M
57. Burg Vogelsang (Eifel)	E	M
58. Wengelsdorf and Laband (Upper Silesia)	E	M
59. Eschentruth (near Kassel)	E	M
60. Hillersleben No. (Borgitz near Braunschweig)	E	M
61. Emschenhagen No. and So. (near Kiel)	E	M
62. Muna-Lehre (Lüneburger Heide)	E	M
63. Basdorf, Wildpark, Hegesee (near Berlin)	E	M
64. Fürstenhagen (near Kassel)	E	M
65. München-Allach (Bayrische Motorenwerke)	E	M
66. Dettlingen Nordenham (near Wilhelmshaven)	E	M
67. Königswartha & Wolfen (Saxony)	E	M
68. Glücksberg (Holstein)	E	M
69. Rheinau & Bitsch (Alsace)	E	M

The Centri-Screen shown in Figure B-11-a is used for screening storm water overflow by-passed at the head end of a clarification plant. The portion of the flow in excess of the plant capacity passes through the rotating perforated screen and is discharged through a lower connection. The screenings retained on the outer surface of the screen are conveyed by the rotating motion of the screen to a pocket from where they are passed to that portion of the flow going to the clarification plant. The screen rotates at a peripheral speed of 0.8 to 1.0 meters per second. The first unit of this type was installed in Frankfurt a Main in 1935. Since then, only five units have been sold.

One type of Passavant bar screen for use in sewage treatment is shown in Figure B-11-b. It consists of a straight bar rack cleaned by means of a rake attached by arms to continuous rotating chains. These chains terminate above water level.

Advantages of this construction are that the action is positive, and there are no moving parts operating in the sewage. However, it requires high head room. The rake cleans the bar rack on the upstroke and descends in a parallel plane away from the bars. Removal of the screenings from the arms is automatic.

A type of bar screen used for water intake screening, illustrated in Figure B-11-c consists of continuous rotating chains to which are attached a number of rakes. The chains extend down to the channel floor. This screen does not require high head room. The rakes on this type unit are cleaned of screenings by either a rotating or a swinging arm.

For fine screening of water intakes a trommel screen as shown in Figure B-11-d is offered. This unit may be circular or approximately oval in shape. The raw or coarse screened water flows from the inside out. Deposited screenings are carried up by fins and are discharged into a trough at the top by means of a water spray.

The Passavant mechanism for cleaning rectangular settling tanks is shown in Figure B-11-c. This unit is of the "Mieder" type, the sludge scraper and skimming blade being suspended on arms attached to an overhead carriage. This carriage runs back and forth on tracks, power being supplied by a flexible cable.

Trickling filter distributors offered are of the conventional type, a possible exception being a six-arm unit

for high rate filters in which three arms are connected to the center column at a higher elevation than the other three so that only one set of three arms is in operation at low flows.

Besides the distributor mechanism, Passavant also cffers underdrains of their own design and manufacture. Details of various types are shown in Figure B-11-f. In type 2, it is claimed that better aeration of the bed will be effected. It is also claimed that psychoda flies can accumulate at the high points in construction so that they can assist in the purification of the sewage passing through the bed.

The Passavant digester mechanism (not shown) consists of distributor arms for spreading the incoming raw sludge. Attached to the ends of distributor arms are vertical arms for breaking down scum. This mechanism is said to rotate at about 60 rpm.

No photographs or drawings were available showing the screenings grinder, the grit remover, or the round clarifier mechanism. The grinder has a heavy horizontal shaft attached to which are teeth that mesh with fixed bars. Grit is removed by means of a traveling bucket elevator. The clarifier is of conventional design using plow rakes.

ITEMS OF INTEREST

The general design features of the centri-screen, bar and trommel screens, filter underdrains, and digester mechanism should be of interest to U.S. engineers and equipment manufacturers.

NEW PROCESSES OR EQUIPMENT

None, except possibly the digester mechanism.

TARGET NO. B-12

<u>Name</u>: Bruer-Werke

<u>Location</u>: Höchst (near Frankfurt am Main)

<u>Date Visited</u>:

<u>Person Interviewed</u>: Chief Engineer

<u>Interviewed By</u>: Fischer, Lt.Col.Gilbert, Sheridan

INFORMATION OBTAINED

The "Breuer-Werke" was formerly the "Geiger'sche Fabrik" of Karksruhe. They took over the patents of Geiger Sr.

At the present time besides slide gates, valves, etc., Breuer makes the following items of equipment for use in sewage and water works:

1. Water intake screens.
2. Sewage screens.
3. Clamshells for grit removal.
4. Rectangular clarifier mechanisms.
5. Trickling filter distributors.
6. Filter dosing tanks.

A typical water screen is shown in Figure B-12-a.

Drawings of the clarifier mechanism were not available. The type of unit offered by Breuer, however, is of the Mieder type.

No recent installations using Breuer equipment were reported.

ITEMS OF INTEREST

None.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-13

Name: Bamag-Meguin

Location: Giessen

Dates visited: July 13, 20, 21, 1945

Persons Interviewed: Dir. Bauer, Henelorf, sewage specialist, Wendt, water specialist

Interviewed By: Dr. Fischer, Lt. Col. Gilbert

INFORMATION OBTAINED

The Bamag-Meguin Company has been bombed out of Berlin, and they have now established a temporary office in Giessen, where they are planning reconstruction for postwar work. This company manufactures mechanical equipment for water and sewage treatment plants as follows:

(a) Mechanically cleaned bar screens: The mechanism for cleaning the screens consists of a unit wherein the rake is raised and lowered by means of a hand operated cable drum. The carriage supporting the rake can be moved horizontally by hand so that racks of any width can be cleaned by a single narrow rake.

(b) Center feed vertical flow grit chambers: Several grit chambers of this type have been installed in Germany. Figure B-22-b (Iserlohn) shows the construction of these chambers, which are circular tanks with concentric baffle walls. The top of the baffle walls are set at different elevations so that a greater portion of the tank comes into use as the flow increases. Theoretically, a nearly uniform upward velocity is maintained in the chambers. The grit is agitated and also removed from the chamber by means of compressed air.

(c) Mechanically cleaned settling tanks: Bamag manufactures sludge collectors for both round and rectangular tanks. One type of collector for round tanks is shown in the figures of Target B-25. The tank as shown is divided into two areas by means of a vertical baffle, the theory being that the heavier material will settle in the inner area and the lighter in the outside area. The sludge from the inner area must be removed oftener than that from the outside area. A

separate collector may be used in the outside area as shown on the illustration or it may be made a part of the main collector. Tanks of this type are claimed to be very efficient. The rakes of the collector can be raised above the water level by means of a cable and hand winch. This feature is said to prevent overloading and stalling of the collector. Collectors are also manufactured for round tanks without an outer area. These proved to be the most widely adopted in actual practice.

Great consideration is given to the distribution of the flow at the center of the tank and also to the sludge collection hopper.

For rectangular tanks Bamag manufactures a Mieder type of collector. The collector of this type is similar to that made by Passavant (see Figure B-11-3). The collector is automatic in that it will make one run up the tank collecting the sludge and scum and then return to the effluent end of the tank with the collecting blades raised and then stop. The collector can be transferred from one tank to the other by means of a transfer car. For primary tanks the detention period is usually 1½ hours and for secondary tanks 2 hours.

(d) Rotary distributors for trickling filters: Distributors designed similar to those used in America are manufactured by Bamag. The filter bed construction, however, is different. The bed drainage systems are constructed of flat precast reinforced concrete slabs with holes approximately 1½ inch diameter, spaced 12-15 inches O/C. The filter material is usually lava rock with a diameter of 80 mm. in the bottom layer. In the center layer the rock is 20 to 40 mm. in diameter and in the top layer the rock diameter is increased to 50 to 60 mm. This increased size in the top layer is to prevent the formation of a clogging mat on the top. The filters are usually 3 to 4 meters deep.

In standard rate filters the loading is usually one-half cbm. of sewage per cbm. of filter rock.

High rate filters are now being designed with a flow of 2½ cbm. per cbm. of filter rock. When these high rate filters are used, the bed is covered with a concrete roof (see Targets B-21, B-22 and B-27, with accompanying Figures). Forced down draft is provided at the rate of 50 cbm. of air per cbm. of sewage. Up draft is not satisfactory due to the flies being sucked into and clogging the impellers of the blower. With this construction the following advantages are claimed:

(1) Filter 1/5 size of standard filter.
(2) Fly nuisance eliminated.
(3) No odors.
(4) Sewage temperature never drops more than 2 degrees below that of the sewage, thus eliminating freezing and maintaining greater biological action in cold weather.
(5) Effluent equal to or better than standard rate open filters.

For small installations the sewage may be distributed on the surface of the beds by means of tipping troughs and lath slats.

(e) Digestion tank equipment: Heating and mixing or stirring equipment for fixed roof digesters is manufactured by Bamag. The usual practice in the design of digesters which are heated and the contents mixed is to allow 45 liters capacity per capita. If the tank is only heated, the capacity must be increased to 60 liters per capita, and if neither heated nor mixed, 90 liters per capita. The tanks are usually heated to 27°C. by means of removable coils.

The mixing equipment is constructed as shown in Figure B-24-c (Essen-Nord). When not furnished with automatic electrical equipment, it is operated one or two times a day. If automatically operated, it rotates 15 minutes in one direction, then 5 minutes in the reverse direction (this clears the impellers), and then rests for one-half to one hour. The impeller is designed so that it will pump from .75 to 1.5 cbm per second, the capacity depending on the size of the tank. The object of the mixing equipment is to break up the scum and mix the upper contents of the tank. The bottom sludge layer is not disturbed.

Figure B-24-c also illustrates the construction of a Bamag digestion tank. At some installations 2 stage digestion is used, at others only single stage. In this design the supernatant liquor is discharged into a combination holding tank and gas holder where it is allowed to cool. The decanted liquor from this tank is returned to the plant and the settled sludge is discharged back to the digester.

A list of the installations which have been made by Bamag-Meguin is attached to indicate the construction work which they have done in the sewage field since 1939.

ITEMS OF INTEREST

The construction of the high rate filters and the sludge digester tanks should be of special interest to American engineers.

NEW PROCESSES OR EQUIPMENT

None.

List of Plants Using Bamag Equipment

(a) City Treatment Plants:

1 Settling tank for Odense (Dänemark)
1 Digester for Uppsala (Schweden)
1 Settling tank for Hamm (Westfalen)
1 " " for Kamen (Westfalen)
2 Digesters for Stockholm (Schweden)

(b) Industrial Treatment Plants:

1 Neutralization Plant for Dynamit AG Kreiburg (Bayern)
1 " " " " Ebenhausen (Bayern)
2 " " " " Christianstadt (Schlesien)
1 " " " " Kaufering (Bayern)
3 " " " " Hessisch-Lichtenau
2 " " " " Allendorf/Lahn
1 " " " " Güsen/Sa.
1 " " " " Clausthal (Harz)
2 " " " Lignose AG Schönebeck/Elbe
1 " " " Pulverfabrik Pionki (Polen)
1 " " " Wasag, Elsnig/Elbe
1 " " " Fettchemie Magdeburg
1 " " " Metallwerk Schlutap

1 Clarification Plant for A.S.W. Böhlen
1 " " " Dr. Otto, Wanne-Eickel
1 " " " Schacht V, Zeche Rheinpreussen

1 Biological Plant for Luranil, Gendorf (Bayern)
1 " " " J. G. Landsberg

1 Clarification Plant for Julienhütte, Bobrek (Schlesien)
1 " " " Thyssen, Hamborn (Westfalen)
1 " " " A.S.W., Espenhain (Sachsen)

1 Biological Plant for Kugellagerfabrik Erkner b. Berlin
- drawing of clarification plant for Prager Eisen-Industrie Kladno (Tschecho-Slowakei)

1 Clarification Plant for Still, Gelsenkirchen (Westfalen)
1 " " " Carolinenglück Bochum(Westfalen)

(c) Military Treatment Plants:

1 Biological Plant for Flugplatz Jesau
1 Stirring Mechanism for Flugplatz Stolp - Reitz
1 Biological Plant for Truppenübungsplatz Stablack
1 Biological Plant for Truppenübungsplatz Wünsdorf

1	Depoisoning	Works	for	Munitions	Plant	Ponarth
1	"	"	"	"	"	Lehre
1	"	"	"	"	"	Zeithain (Riesa)
1	"	"	"	"	"	Priebus
1	"	"	"	"	"	Wilhelmshaven

TARGET NO. B-14

<u>Name</u>: Mashinenfabrik - H. Geiger

<u>Location</u>: Karlsruhe, Germany

<u>Dates Visited</u>:

<u>Persons Interviewed</u>: H.Geiger,owner; Hans Eichrodt, chief engr.

<u>Interviewed By</u>: Lt.Col. Gilbert, Lt. Pfreimer

INFORMATION OBTAINED

The Geiger Mashinenfabrik is a manufacturer of mechanical equipment for sewage treatment plants, water plants, industrial waste, and process water treatment plants.

The following equipment is manufactured by this company:

(a) Mechanically cleaned bar screens for sewage or process water treatments in two designs.

(1) For large plants the screen is constructed as shown in Figure B-14-a. These screens are made of varying widths and heights, the maximum width being 4 meters and the maximum depth 12 meters. The width of the screen is selected so that the velocity through the clear openings will be 50 cm per sec., for process water and a little less for sewage. It will be noted that the moving parts of the cleaning mechanism are always above the water level. The screenings after being discharged are conveyed by a belt conveyor to a cart at the side for subsequent disposal.

(2) For small plants a different type of cleaning mechanism is used due to desire for economy in fabrication. This mechanism is illustrated in Figure B-14-b. The mechanism consists of two pair of arms with rakes attached. The arms rotate and clean the rack which is curved to the same radius as the rake arms. The maximum width of this screen is 1.5 meters and the maximum depth 1.5 meters. It will be noted also on this screen that all moving parts are above the water level.

(b) Mechanically cleaned screens for process or other relatively clear waters: This screen is illustrated in Figure B-14-c, and is constructed with a maximum width up to 3 meters and a maximum depth of 12 meters. The rack is constructed of a spirally constructed heavy wedge shape wire which is twisted around a wire core every 3" to 4" to provide the spacing of 1½ to 5 mm clear openings. The width of the screen is determined so that the velocity through the rack will be about 75 cm. per second. The screen is cleaned by brushes which are conveyed up the face of the screen by endless chains.

(c) Storm water screens. These screens are illustrated in Figure B-14-d. Their purpose is to screen the storm water flow that is by-passed direct to the river without passing through the treatment plant. The channel "A" passing through the screen carries the dry weather flow but the storm water flow spills into the inside of the screen. This water fills compartment "C" until it flows into channel "B". At this level a float automatically starts the screen and wash water pump. By means of a spray the screenings are washed from the screen back to channel "A". The screen and pump stop when the compart "C" is emptied of water. It will be noted that the screen is supported on rollers above the water level.

This screen is constructed up to 3.2 meters in diameter and 5 meters in length of milled plates or wire as in (b) above, with 5 mm to 2 mm openings. The design velocity through the openings at the maximum flow is 0.5 meter/second.

(d) Cooling water screens. For screening river water which is used for cooling purposes, a screen of the same construction as (c) above is used. The maximum size of the screen is the same with the exception that the openings do not exceed 1.0 mm. The flow enters the center of the screen and passes out through the sides.

(e) Process water screens. Where it is necessary to screen large quantities of river water for manufacturing processes or for water treatment plants the endless tray type of screen is used.

The flow enters the screen at a point between the vertical trays and passes out through the sides, thus utilizing both sides of the screen. The maximum width of these screens is 3 meters with a maximum depth of 12 meters. The openings in the woven mesh screening cloth are 0.05 to 1.0 mm. The average velocity for which the screens are designed is 0.5 meter/second.

In some process water screening plants three types of screens may be used. They are:

(1) A coarse hand cleaned screen with 60 mm clear openings.
(2) A mechanically cleaned screen with 5 mm clear openings as in (b) above.
(3) A mechanically cleaned process water screen with 0.5 mm clear opening as described above.

(f) Tangential flow grit chambers. Engineer Geiger has studied the various types of grit chambers now in use and has developed the tangential chamber as shown in Figure B-14-3. These chambers are built in sizes up to 10 meters in diameter. The detention period is one minute.

The sand which settles in the bottom of the chamber is agitated and washed for 10 minutes in the chamber by 2 cbm/hour of air for small chambers and 5 cbm/hour for large chambers. After the agitation and washing the discharge valve is opened and the same air then elevates the sand and water to a storage hopper. The water is returned to the chamber by overflowing the hopper.

(g) Settling tank sludge removal mechanisms. Equipment for both round and rectangular tanks is made.

(1) Round tanks. For round tanks a spiral sludge collection blade is used as shown in Figure B-10-i (Niers District). The carrying truss is rotated by means of a gear on the outer wall in order to secure positive action. The sewage or other waste water enters the tank through a siphon which discharges in the center of the tank. A large sludge collection well is provided in the center of the tank so that sludge will be concentrated and it can be removed intermittantly. It is claimed by the manufacturer that one revolution will remove all the sludge from the bottom of the tank.

A two-hour detention period is usually provided for sewage treatment.

These collectors are made for tanks up to 50 meters in diameter and 3 meters deep, the minimum diameter being 15 methers. For tanks under 15 meters in diameter a single blade collector is used.

(2) Rectangular tanks. For rectangular tanks the Mieder type of sludge collector with scum skimmer is manufactured as shown in Figure B-14-f. These collectors are automatic in that they make one run up and down the tank and then stop. They can then be transferred from one tank to another, thus reducing initial cost of construction. In large installations a transfer car is used while at small installations the collector is pushed from one tank to the other. The collectors travel at 5 to 10 cm/second when scraping and at 30 cm/second when returning.

The normal width of these collectors is 10 meters with a minimum of 15 and a maximum of 20 meters. The usual depth is 3 meters.

A detention period of 2 hours is usually provided. Experience has shown that operation once or twice a day is sufficient.

A different Mieder type of sludge collector has been designed. This type of collector has not been built as of this date. This type of collector is equipped with a pump so that the sludge can be pumped from in front of the scraper blade as it moves along the floor of the tank. No sludge hoppers are provided in these tanks.

In order to form an opinion as to the type and the amount of work which has been done by this company in the water and sewage field since 1938, a complete list of the equipment manufactured by this company is attached.

GENERAL OBSERVATIONS

American manufacturers make similar equipment to that described above. However, many of the details are different and should be interesting to these manufacturers.

ITEMS OF INTEREST

Design of tangential flow grit chamber and details of mechanical equipment.

NEW PROCESSES OR EQUIPMENT

None.

Maschinenfabrik H. Geiger Installations-1938 to 1945

Name	Type	Use
Maschinenfabrik Augsburg-Nürnberg Werk Augsburg	1 fine screen	Cooling water
Elektrizitätswerk Posen	4 " screens	" "
Märkisches Elektrizitätswerk Akliengesellschaft Berlin	8 " "	" "
Zellstoff Waldhof	1 " screen	" "
Köhnke Bremen Elektrizitätswerk	2 " screens	" "
Stadtwerke Breslau Elektrizitätswerk	1 " screen	" "
Bayerische Elektrizitäts-Lieferungs-Gesellschaft Bayreuth, Kraftwerk Arzberg	2 " screens	" "
Tiefbauamt Karlsruhe:/B Kläranlage Neureut	1 " screen	Sewage screen
Grosskraftwerk Mannheim Elektrizitätswerk	2 " screens	Cooling water
Amoniakwerk Merseburg G.m.b.H. Leuna Werke	1 " screen	" and process water
Hytrierwerke Pölitz in Pölitz	8 " screens	Cooling and process water
Energie-Versorgung Schwaben Stuttgart Kraftwerk Marbach	4 " "	Cooling water
Heizkraftwerk Stuttgart Elektrizitätswerk	2 " "	" "
Deutsche Bergwerks und Hüttenbau Gesellschaft M.B.H. Hütte Linz	7 " "	" "
Mineralöl-Bau-Gesellschaft Berlin	4 " "	" "

Name	Type	Use
Mineralöl-Bau-Gesellschaft Berlin	4 tray screens	Cooling water
Deutsche Bergwerks und Hüttenbau Gesellschaft M.B.H. Hütte Linz	7 " "	" "
Aktiengesellschaft Dresden Elektrizitätswerk Hirschfelde	3 " "	" and process water
Elektrizitätswerk Posen	4 " "	Cooling water
Technische-Werke Stuttgart Kraftwerk Münster	4 " "	" "
Energie-Versorgung Schwaben Stuttgart Kraftwerk Marbach	4 " "	" "
Deutsche Bergwerks-und Hüttenbau Gesellschaft M.B.H. Hütte Linz	4 coarse screens	" "
Oberbürgermeister der Stadt Cottbus Kläranlage	2 " "	Sewage
Heinrich Scheren Düsseldorf	1 " screen	" for chem. industrie
Ruhrverband Essen Kläranlage Rellinghausen	1 " "	Sewage
Weiselsterverband Gera	1 " "	"
Spinnerei und Weborrei Offenburg	3 " screens	Process water
Tiefbauamt Stuttgart Kläranlagebetrieb	1 " screen	Sewage
Niersverband Viersen Schloss Vissen	2 " screens	Process water
Tiefbauamt Berlin Kläranlage Stahnsdorf	1 " screen	Sewage
Kläranlage Wuppertal	2 " screens	"
Aquapura Berlin	1 " screen	"
Hilscher und Hanselt Graz	1 " "	"

Name	Type	Use
Reis u Co. Mannhein	1 coarse screen	Sewage
Schimmel Miltitz	1 " "	"
Tiefbauamt Villingen Kläranlage	1 " "	"
Tiefbauamt Mannheim Kläranlage: Regenauslass	1 drum screen	"
Tiefbauamt Köln Kläranlage: Regenauslass	2 " screens	"
Deutsche Ramie-Gesellschaft Emmendingen	2 " "	Cooling water
I. G. Farben Leverkusen	2 " "	Process water
M.A.N. Augsburg Maschinenfabrik	1 " screen	Cooling water
Heizkraftwerk Stuttgart Elektrizitätswerk	3 tray screens	" "
Niersverband Viersen Kläranlage Nersen	Sludge removers 6 round tanks	Sewage
Tiefbauamt Stuttgart Kläranlage Mühlhausen	Sludge remover 1 round tank	"
Deutsche Bergwerks und Hütten-baugesellschaft M.B.H. Hütte Braunschweig	Sludge remover 2 round tanks	Coke water
Ruhrverband Essen Kläranlage	Sludge remover 1 round tank	Sewage
Der Oberbürgermeister der Städt Taucha Kläranlage Toucha	Sludge remover 1 rectangular tank	"
Der Oberbürgmeister der Stadt-Düsseldorf Kläranlage Lörick	Sludge remover 1 rectangular tank	"

TARGET NO. B-15

Name: Maschinenfabrik-Esslingen

Location: Esslingen am Neckar

Date Visited: August 9, 1945

Person Interviewed: Chief engineer on gas compression stations

Interviewed By: Lt.Col. Gilbert, Lt.Pfreimer, Maj. Tatlock

INFORMATION OBTAINED

In Germany compressed sewage gas is being extensively used to operate automobiles. Of the 40 sewage gas compression installations that have been made, all but about 3 have been made by the target company. The first plant was installed in 1936, and as the war progressed and gasoline became more difficult to obtain the number of installations increased rapidly. This company has set for its goal the use of decaying organic matter of every kind to produce gas. This includes not only sewage sludge but barnyard manures and other organic matter.

A typical installation layout is shown in Figures B-15-a to B-15-c, inclusive. The gas is processed in the following steps (see Figure B-15-a):

(a) Filtered by steel wool or oil screens to remove dirt. (b)
(b) Metered. (c)
(c) Pressure compensation or storage. (f)
(d) Compressed in 2 stages to 14 atmospheres. (h)
(e) Washed by water to eliminate H_2S and CO_2. (r)
(f) Further compressed in two additional stages to 350 stmospheres. (h)
(g) Stored in steel cylinders at 350 atmospheres. (N & O).
(h) Delivered to consumers at 200 atmoshphers.(Z) in cylinders holding 10 to 16 cu. meters of gas.

The cost of compressing 1 cu. meter of gas is approximately 0.06 to 0.07 mark, including amortization, and depending on local conditions. The cost of a complete installa-

tion including building and equipment for a plant to compress 180 cu.m./hour would be approximately 50,000 marks. The equipment cost for equipment alone as furnished by Maschinenfabrik Esslingen would be 30,000 marks. One cu. meter of the washed sewage gas equals 1.2 cu. liters of gasoline.

GENERAL OBSERVATIONS

The use of sewage gas for the operation of automobiles has increased in Germany during the war. This increase has been due to the shortage of gasoline and not because its use has any advantage over the use of gasoline. Sewage plants have been remodeled and built for the specific purpose of increasing the gas supply or of furnishing a new source of gas.

The readily available quantities of gasoline in the U.S., will limit the adoption of the use of compressed sewage gas in America.

ITEMS OF INTEREST

The design of equipment furnished by this company should be of interest to U.S., engineers.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-16

Name: Bopp and Reuther G.m.b.H.

Location: Mannheim-Waldhof

Date Visited: July 24, 1945

Person Interviewed: Asst. Director Wegscheider

Interviewed By: Lt.Col.Gilbert, Lt. Pfreimer, Dr. Sheridan

INFORMATION OBTAINED

Bopp and Reuther manufacture fittings, valves, and metering devices for water and sewage plants. During the war this company continued to manufacture these regular items and did not manufacture special war materials. Bopp and Reuther export their products to many foreign countries, including South America, Japan, Canada and Australia. Business is not done in the U.S.

In order to illustrate the various water and sewage works items manufactured by this company, the following catalogues and pamphlets in English have been obtained:

(a) "BSR Pipe Burst Safety Devices". This 62-page book describes shut-off devices, release devices, testing devices, devices for obtaining smooth closing, etc.

(b) "Optima Easy Flow Valve 201" (German patent). This one sheet advertisement illustrates the above valve.

(c) "B & R Differential Manometer". (One sheet description).

(d) "B & R Venturi Flume Meter". (One sheet description). This meter is used to measure flows of fluids in open channels and pressureless pipelines.

(e) "Liquid Level Indicator and Recorder". A 4-page description of various arrangements.

(f) "B & R Venturimeter". A 4-page description of various arrangements.

(g) "B & R Metering Stream Lines Needle Valves". A 4-page description of this combination metering appliance and shut-off device.

(h) "The New Large Optima 101". A 12-page description of a patented inferential water meter of 2" to 6" diameter for measuring water at installations having large fluctuations in consumption.

(i) "Oval Wheel Meters". A 40-page description of these highly accurate volumetric measuring meters.

GENERAL OBSERVATIONS

The short tube venturi as manufactured by this company was seen at the Hagen water plant. It is claimed that this meter gives accuracy comparable to the long tube type. (See reprint from "Engineering", 8 November 1935).

The "Optima" meter appears to be a simple, well-built meter, cheap to construct.

ITEMS OF INTEREST

The various items of equipment manufactured by this company should be of interest to U. S. engineers and manufacturers. Copies of the various catalogues and pamphlets referred to are being transmitted to the U.S., so that interested parties may examine them in detail.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-17

Name: Leipzig-Rosenthal Sewage Treatment Plant

Location: Leipzig

Persons Interviewed: Engineers Ehlers, Müller

Interviewed By: A. E. Gorman

INFORMATION OBTAINED

In greater Leipzig the present average dry weather flow amounts to 75,000 cu. m. per day. Of this 60,000 cu.m. per day is treated in the Rosenthal plant; 56,000 cu.m. per day of the plant effluent is pumped to sewage farms, the remainder being discharged direct to the Elster River. During the war flows treated applied to the fields and discharged to the river, were 115,000, 80,000, and 35,000 cu.m. per day respectively.

The plant consists of mechanical cleaned bar screens, mechanically cleaned grit chambers and longitudinal settling tanks equipped with Mieder type sludge collectors, one mechanism serving several tanks. The sludge from the settling tanks is pumped to lagoons.

Before the war all the settled effluent was chlorinated and discharged to the Elster River. During the war chlorine was not available.

Plans were under way to construct a new settling tank, digestion tanks and a gas recovery system. The digesters planned were two in number, each of 2000 cu.m. capacity. One was to be equipped with a BAMAG (Prüss) stirring mechanism; the other with an A. G. Hering sludge distributor.

The sewage farms are located at Hohenossig, 13 kilometers north of Leipzig. The area served is under a corps of peasant farmers (Abwasser Verband Deutsch) a foundation capitalized by the City of Leipzig and the German Government. The peasants construct dikes, and operate the valve chambers, outlets, etc. They also harvest the crops

raised on the land. The crops consist of potatoes, rye, wheat, sugar beets, cabbage, colza and grass clover.

The area irrigated is 20,000 hectares. By the use of sewage for irrigation the increase in crop growth was said to be 60-100%.

GENERAL OBSERVATIONS

The only damage suffered at the treatment plant was to the machine and storage house which was destroyed in August 1944.

ITEMS OF INTEREST

None.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-18

Name: Halle Sewage Treatment Plant

Location: Halle

Date Visited: June 7, 1945

Person Interviewed: Dr. Ing. W. Müller

Interviewed By: A. E. Gorman

INFORMATION OBTAINED

The Halle plant was designed to treat a dry weather flow of 260 liters/sec., from a contributing population of 225,000. It consists of bar screens cleaned with Passavant mechanisms; five plain grit chambers; eight single pass and four double pass Imhoff tanks providing a two-hour detention period; and 5400 cu. m. of digestion capacity; six separate sludge digestion tanks having a total capacity of 3900 cu. m., and 12 sludge drying beds, six of which are 15 meters x 80 meters in area, five 7.5 m. x 40 m. and one 14 m. x 100m. In addition there are four sludge lagoons, a sludge-fertilizer plant; a gas purification plant, and small activated sludge and digester test plants.

Screenings, amounting to 3 cu. meters/day are mixed with grit and used as fertilizer. Sludge is pumped from the Imhoff tanks at 95% moisture and is withdrawn from the separate digesters at 93%. On the sand beds this moisture is further reduced to 50-55%.

The No.1 digester battery (2 tanks) has a capacity of 1000 cu. meters. They are heated to 25° - 28° by copper heating coils arranged spirally on the conical hopper bottom. Both units of this battery were equipped with Imhoff type submerged covers. A layer of scum about 30 cm thick was at the surface of each unit.

The No.2 battery had a total capacity of 1200 cu. meters, and had fixed concrete covers. They were also heated to 25° - 28°C. During the winter months the temperature of all the tanks dropped to about 20°C.

Gas from the Imhoff tanks and from the separate digestion tanks contained an average of 65% CH_4, 34% CO_2 and 17% H_2 with 0.0 - 0.1% H_2S. It was scrubbed for H_2S removal in three bog iron ore boxes each 2 x 3 x 1.5 meters. The gas, amounting at present to 1700 cu. meters/day, has a heat value of 6500 calories per cu. meter. Prior to the war part of the gas (3700 cu. meters/day total) was compressed and pumped at 1.0 atmosphere to the local gas work for further purification and use in the city gas mains. The remainder was used for heating the digester and for operating the gas pumps and compressors.

Mercaptans were fed into the gas delivered to the gas work so that any leaks in the lines, etc., might be readily detected and accidental asphyxiation avoided. The mercaptans were added at the rate of 3 drops per minute for a gas quantity of 2150 cu. meters/day in an apparatus supplied by BAMAG. The solution added consisted of 1 part mercaptans to 9 parts alcohol.

During the war, in order to make the maximum amount of gas available for CH_4 production, coal was used for heating the digesters.

Recent research work consisted of studies of methods for increasing methane production by digestion. Various materials such as leaves, organic matter from industry, "sweet wood" containing licorice, etc., were being added. No favorable results were reported.

GENERAL OBSERVATIONS

The plant had not been damaged by bombing. It was, however, operating at reduced capacity due to breaks in sewers.

ITEMS OF INTEREST

The use of gas in the city mains and the adding of mercaptans to warn against leaks.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-19

Name: Hagen Sewage Treatment Plant

Location: Hagen (in Ruhrverband)

Date Visited: July 4, 1945

Person Interviewed: Plant Operator

Interviewed By: Fischer, Gorman, Lt.Col.Gilbert, Sheridan

INFORMATION OBTAINED

The Hagen plant (see Figure B-19-a) is of the primary treatment type followed by fish ponds. It consists of screens, grit chambers and Imhoff tanks with a Prüss digester constructed later. During the war facilities were added for compressing the digester gas for use in driving automobiles.

The gas recovery and utilization system consists of a gas holder with Machinefabrik Esslingen gas compression equipment. The gas was washed with water to remove carbon dioxide and compressed in stages up to 350 atmospheres. The receiving cylinders were of two sizes - 40 and 60 liters capacity. The smaller cylinder held 8 cu. meters of gas under standard conditions while the larger ones held 12 cu. meters. According to the plant operator, the gas was sold for 4 marks per cu. meter. One cubic meter of gas was said to be equivalent to one liter of gasoline.

GENERAL OBSERVATIONS

This plant was in a poor state of repair although no bomb damage had been suffered.

ITEMS OF INTEREST

Except possibly for the gas compression equipment there was nothing new at the plant which can be considered of value for use in the U.S.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-20

<u>Name</u>: Essen-Rellinghausen Sewage Treatment Plant

<u>Location</u>: Essen (in Ruhr District)

<u>Date Visited</u>: June 28, 1945

<u>Person Interviewed</u>: Dr. Sierp

<u>Interviewed By</u>: Fischer, Gorman, Sheridan

INFORMATION OBTAINED

This is an old plant that has been repeatedly described in the literature. It consists of screens, plain grit chambers, grease flotation tank, Imhoff tanks, Dorr primary clarifier, aeration tanks equipped with Imhoff paddle aerators, secondary settling tanks, separate sludge digestion tanks, a gas holder, and gas engines for generating power to operate the plant. **Figure B-20-a.**

The normal flow to the plant was 380 cu. meters per second. The present flow is about 180 cu. meters per second. The present gas production is 800-1000 cu. meters per day.

GENERAL OBSERVATIONS

This plant was in a very bad state of repair although it suffered no direct bomb damage. Only a corner of the primary clarifier had been damaged by shell fire. Only the Imhoff tanks were in operation when the plant was visited.

ITEMS OF INTEREST

None.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-21

Name: Heiligenhaus Sewage Treatment Plant

Location: Heiligenhaus (in Ruhr District)

Date Visited: June 30, 1945

Person Interviewed: Mr. Fries, plant operator

Interviewed By: Fischer, Gorman, Sheridan

INFORMATION OBTAINED

This was a small plant consisting of bar screen, plain grit chamber, Imhoff tanks, enclosed trickling filter and plain circular (Dortmund type) final settling tank. No information was available on flows or plant results.

Sewage was distributed on the trickling filter bed by a four-arm rotary distributor. Forced down draft ventilation was provided by a fan located on the roof of the filter housing. The filter stone depth was 3-4 meters.

GENERAL OBSERVATIONS

The plant suffered no bomb damage and was well kept up. No odors were noticed around the plant which was located adjacent to many houses. Neither were psychoda flies in evidence. When the door in the filter housing over the filter stones was opened, a swarm of filter flies was blown out, and it was noted that the air blown from the house was very odorous. Evidently the odors and flies are destroyed in passing thru the filter bed.

The final effluent was brownish in color and was turbid. It was estimated that its 5 day BOD was about 70-80 ppm. The raw sewage was fairly strong averaging about 300-400 ppm.

ITEMS OF INTEREST

The enclosed filter was of interest because of its neat appearance and lack of exterior flies or odors.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-22

Name: Iserlohn Sewage Treatment Plant

Location: Iserlohn (in Ruhr District)

Date Visited: July 5, 1945

Person Interviewed: Plant operator

Interviewed By: Fischer, Lt.Col.Gilbert, Gorman, Sheridan

INFORMATION OBTAINED

The Iserlohn plant (see Figure B-22-a), serving a pre-war population of 45,000 was originally of the activated sludge type consisting of a plain bar screen, storm water, tanks, a deep grit chamber (see Figure B-22-b), primary Imhoff tanks, aerators with Imhoff type paddle aerators, and hopper bottom final settling tanks.

In 1938, two enclosed trickling filters were constructed to replace the aeration tanks which are now used for sludge storage. The enclosed filters (see Figure B-22-c), are 22 meters diameter x 4 meters stone depth. They are completely covered and provided with fans in the roof to give down draft forced ventilation. Each filter is provided with rotary distribution having four arms, two of which have "goose-necks" near the center column so that only two arms are in operation at times of low flow.

The final tanks, four in number, are of the "Dortmund" type, and are equipped with asbestos effluent weirs and feed pipes.

GENERAL OBSERVATION

No flow data or analytical results were available on this plant. The raw sewage, however, appeared to be strong (about 400-500 ppm BOD). The final effluent contained considerable suspended solids. Its BOD is estimated at 70-100 ppm.

Due to artillery fire, some glass tiles were broken at the top of one of the filter structures. The top manholes in both structures were open. The ventilation fan in only the undamaged filter was in operation. All the air, however,

was expelled thru the top manhole. Odors at the manholes were considerable, but fly nuisance was negligible.

ITEMS OF INTEREST

The enclosed filters at this plant present an attractive structure but results observed cannot be considered representative as the units were not operating normally.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-23

Name: Hättingen Sewage Treatment Plant

Location: Hättingen (in Ruhr District)

Date Visited: July 2, 1945

Person Interviewed: Plant Operator

Interviewed By: Fischer, Lt.Col.Gilbert, Gorman

INFORMATION OBTAINED

This plant was originally a two-stage contact aerator plant built in 1929. It was remodelled in 1936, activated sludge being substituted for the contact aerators. An original grease flotation tank with Imhoff pendulum type aerator was also abandoned.

The plant as now constituted consists of a plain bar screen and grit chambers, mixing tanks for mixing sewage and industrial (phenol) wastes, low lift pumps, primary Imhoff tanks, aeration tanks with spiral flow aeration (see Figures B-23-a and B-23-b), final settling tanks, horizontal cylindrical separate sludge digestion tank with rotating heating coil (Figure B-23-c), gas holder, gas engines for power generation, and sludge drying beds. The effluent from the final settling tanks is run to fish ponds.

The normal population contributing to the plant is 17,000. With industrial wastes present the average sewage flow amounts to 110-120 liters/sec. Without trade wastes the flow is 75-95 liters/sec. The low lift pumps are three in number, two delivering 85 liters/sec., and the third 120 liters/sec. The compressors deliver 720 cu. meters of free air per hour. The return sludge amounts to 12%, the aeration period being 3½ hours. The final settling period is about 1½ hours. The capacity of the gas holder is 120 cu. meters. This is about equal to a normal day's gas production.

The digester contents are normally held at a temperature of 32-34°C by heating water from the gas engine jacket. The normal quantity of sludge delivered to the tank was said to be 450-500 cu. meters/day. Gas is collected from the Imhoff tanks and from the separate digestion tank. Due

to a break in the gas line running from the gas holder, the gas engine that drove one of the blowers was not in operation.

According to information supplied by the Ruhr district engineers the original contact aerators (Tauchkörpers) were abandoned because of their high operating cost and sensitivity to strong sewage containing industrial wastes. The air consumption was said to be 10 cu. meters per cu. meter of sewage treated. The air consumption was cut in half by use of the activated sludge process.

GENERAL OBSERVATIONS

No analytical results were available but the final effluent appeared to be of good quality. The plant appeared to be in a somewhat better state of repair than other installations in the Ruhr and Emscher districts.

The plant suffered no bomb damage and was the only activation plant seen where the aeration system was in full operation.

ITEMS OF INTEREST

The demonstrated superiority of activated sludge treatment over contact aerators on the same type sewage should be of interest to U.S., engineers in view of the large number of contact aerator (Hayes) plants built in the U.S., during the war years.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-24

Name: Essen-Nord Sewage Treatment Plant

Location: Essen (in Emscher District)

Date Visited: June 29, 1945

Persons Interviewed: Emscher district officials

Interviewed By: Fischer, Gorman, Sheridan

INFORMATION OBTAINED

This plant shown in Figure B-24-a, is an old one consisting of screens, grit chamber, Imhoff tanks, Bamag (Prüss type) settling tanks, Prüss type digesters (see Figures B-24-b and B-24-c), gas holder and gas compressor equipment. The gas compressors were added during the war in order to make the gas available for automobile fuel.

GENERAL OBSERVATIONS

This plant was very poorly maintained during the war and suffered very heavy bomb damage as it was located close to important war industries. Damage to the plant was chiefly to the Imhoff tanks and to the gas compressor station. The gas holder and the Prüss settling tank were also slightly damaged. The plant was entirely out of operation as a result of this damage.

ITEMS OF INTEREST

None.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-25

Name: Alte-Emscher Sewage Treatment Plant

Location: Duisberg-Alsum (in Emscher District)

Date Visited: June 30, 1945

Persons Interviewed: Emscher district officials, plant operator

Interviewed By: Fischer, Gorman, Sheridan

INFORMATION OBTAINED

The Alte-Emscher plant (see Figure B-25-a), treats sewage and waste chiefly from surrounding industrial plants. It consists of a single circular Bamag (Prüss) settling tank 68 m. diameter. The sludge from this unit is pumped to lagoons.

GENERAL OBSERVATIONS

When the plant was visited it was out of operation due to extensive bomb damage to the settling tank and to two 1.6 meter diameter inlet pipes.

The construction of the Prüss type tank and mechanism appeared to be exceedingly complicated. (See Figures B-25-b, B-25-c, B-25-d). The effluent take off as shown in Figure B-25-3), was unique in that it consisted of a series of floating bells arranged around the outer tank wall and discharging into an outer peripheral channel. This type of take off was used in order to avoid difficulties with conventional overflow weirs in case uneven tank settlement occurred.

ITEMS OF INTEREST

The general construction features of this Prüss type mechanism are of interest although it is questionable whether it would find application in the U.S., because of its complications. The method of effluent is simiarly of some interest.

NEW PROCESSES OR EQUIPMENT

This latest design of Prüss tank, although not generally known in the U.S., is not new.

TARGET NO. B-26

<u>Name:</u> Karnap Plant

<u>Location:</u> Karnap (in Emscher District)

<u>Date Visited:</u> June 29, 1945

<u>Persons Interviewed:</u> Emscher district officials

<u>Interviewed By:</u> Fischer, Gorman, Sheridan

INFORMATION OBTAINED

The Karnap works, shown in Figures B-26-a and B-26-b, is an old plant in which the entire Emscher River is settled for two hours in four longitudinal settling basins. The normal dry weather flow is 10-12 cu. meters/sec. Sludge is removed by hydraulic dredges and run to lagoons. In the lagoons the sludge dried to 40% water. Of the remaining 60%, one-half is ash and one-half is organic matter having a fuel value. Attempts were made to use this material at the Essen-Karnap power plant during the war emergency, but results were not good as this plant was not designed to handle this grade of fuel. The dried sludge was used for domestic heating in nearby houses with some success. During the period of low summer flow the coal content of the sludge is highest.

GENERAL OBSERVATIONS

When the plant was visited two basins were out of operation due to bomb damage.

ITEMS OF INTEREST

None.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-27

Name: Soest Sewage Treatment Plant

Location: Soest (in Lippe District)

Date Visited: June 19, 1945

Persons Interviewed: Dr.Husmann, chemist, Emscher & Lippe Dist.

Interviewed By: A. E. Gorman

INFORMATION OBTAINED

This plant treating sewage from a population of 25,000 is shown in Figures B-27-a to B-27-f incl., and consists of a plain bar screen, grit chamber, two plain longitudinal primary settling tanks, three enclosed trickling filters, a combination activation-final settling tank, and fish ponds. Sludge is digested in a separate digester located between the two primary settlers. The digester contents are stirred by means of two Prüss mechanisms. Digester gas is used for power generation.

The plant was originally constructed in the early 1930's, the trickling filter being of the open type. In 1936-37, the filters were enclosed and provided with downdraft forced ventilation.

Results of a one day's test before and after the filters were enclosed are given in table 1.

Flows are not given for these two periods, but it is inferred that before the filters were enclosed, the flow averaged 4400 cu. meters/day as against 6000 cu. meters/day after they were enclosed. In any event, a one day's test cannot be considered as representative of trickling filter operation and too much reliance should not be placed on this comparison.

GENERAL OBSERVATIONS

This plant suffered no bomb damage but was operating at reduced flow when it was visited, so that visual observation of the plant efficiency under normal operating conditions was not possible.

ITEMS OF INTEREST

The enclosed filters may be of interest to U.S. engineers as should also the use of the activated sludge process following trickling filter treatment at higher than normal dosing rates.

NEW PROCESS OR EQUIPMENT

None.

Table 1.- Soest - Comparison of Results Before and After Filters were Enclosed

	Raw sewage ppm		Settled sewage ppm		Filter effluent ppm		Final effluent ppm *	
	Before	After	Before	After	Before	After	Before	After
Total suspended solids	352	-	110	-	77	-	18	-
Organic suspended solids	253	-	100	-	49	-	17	
Total dissolved solids	1190	-	1120	765	1080	722	1045	783
Organic dissolved solids	270	-	230	238	100	199	100	215
BOD 5 days	390	-	350	222	30	14	15	7
NH_3	27	-	28	19	5	7	4	6
$NO_2 + NO_3$	-	-	-	1	5	10	15	10
Org. N	28	-	20	10	3	2	2	2

* Clarification of fish ponds not noted.

TARGET NO. B-28

Name: Frankfurt Sewage Treatment Plant

Location: Frankfurt a Main

Date Visited: July 11, 1945

Persons Interviewed: Dir. E. Hübner, Supt. J. Klos

Interviewed By: Fischer, Lt.Col.Gilbert, Sheridan

INFORMATION OBTAINED

The main sewage treatment works at Frankfurt was designed to treat the sewage from 400,000 people. The original plant consisting of plain settling tanks was built in 1880-85. In 1902, the settling tanks were enlarged and mechanized bar screens and grit chambers added. In 1909, ten Meer sludge centrifugals were installed. In 1923-24, open digestion tanks were added.

The plant now consists of coarse screen racks with 6" openings, plain grit chambers with bucket elevator and travelling crane for grit removal, three mechanical bar screens with rotating 5 radial arm cleaning mechanism, 28 plain settling tanks (hand cleaned), open digesters, and sludge drying beds. Raw sludge is pumped to the digesters by means of pneumatic ejectors, shown in Figure B-28-a.

GENERAL OBSERVATIONS

This plant is out-of-date and is greatly overloaded. Due to bombing, part of the settling tanks were out of operation. The 10 Meer sludge centrifugals and housing were completely destroyed.

ITEMS OF INTEREST

The engineers stated that the centrifugals when in use gave a raw sludge cake of 60% moisture. Objectionable features were the odors produced and the production of centrifuge liquor containing 5% solids. Partial digestion aided in the odor problem but still gave a poor quality liquor. It was stated that any future plant construction program would contemplate the use of vacuum filters instead of centrifugals.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-29

Name: Hildesheim Sewage Treatment Plant

Location: Hildesheim

Date Visited: July 8, 1945

Person Interviewed: Plant Operator

Interviewed By: Fischer, Lt.Col.Gilbert, Gorman, Sheridan

INFORMATION OBTAINED

This plant served a prewar population of 50,000. The present population is about 25,000. The plant, constructed in the 1920's consisted of: (a) homemade mechanical screen of rotating wire links with approximately 1/2" openings (see Figure B-29-a). The screenings were brushed off and removed by a screw conveyor to a cart; (b) Kremer-Kusch vertical flow settling tanks; (c) open trickling filters with rotary distributors, and (d) separate Kremer-Kusch digestion tank. This tank is circular in plan and is divided into 16 compartments by means of an inner circular wall and by radial walls. Raw sludge is pumped to the inner 8 compartments from where it flows to the outer compartments before being discharged to the drying beds.

Supernatant liquor from the secondary digester compartments is discharged to a rock filter bed 3 meters square x 1.5 meters deep before it is discharged direct to a canal. The filter stones are about 2" in size. The supernatant is applied to the rock filter by a stationary distribution grid consisting of half pipes in which V-notches are cut. This filter is shown in Figure B-29-b. The filter effluent is discharged direct to the receiving stream without secondary settling.

GENERAL OBSERVATIONS

This plant was greatly overloaded as evidenced by visual observation of the effluent. It suffered no war damage and was in a fair state of repair.

ITEMS OF INTEREST

The items of interest at this plant were the unique digester structure and the method of handling the supernatant liquor. Due to its structural complications it is questionable whether the digester would be of interest in the U.S. The digester supernatant treatment method may have merit. Unfortunately, however, no data regarding it were available.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-30

Name: Berlin Stahnsdorf Sewage Treatment Plant

Location: Berlin

Date Visited: July 26, 1945

Person Interviewed: Mr. Thiele

Interviewed By: Dr. Fischer

INFORMATION OBTAINED

This plant was built about 1930, and consists of mechanically cleaned bar screens, grit chambers with mechanical grit removal, primary settling tanks equipped with sludge removers, aeration tanks, final settling tanks, separate sludge digestion tanks, gas holders and gas compression equipment. Digested sludge is dried on sand beds.

This plant was originally built as an experimental installation wherein comparisons could be made between various types of tanks and mechanical equipment. The only additions made since the plant was originally constructed were for the gas compressor installation so that the gas could be used for driving automobiles.

Capacities of the various plant units are:

Primary settling tanks	-	17,100 cu. meters
Aeration tanks	-	28,000 " "
Final settling tanks	-	8,016 " "
Digestion tanks	-	33,000 " "

Average flows, etc., for the year ending March 31, 938, were:

Connected population	- 240,000
Flow to primary treatment	- 58,510 cu.meters/day
Flow to secondary treatment	- 11,239 " " "
Screenings	- 2.11 " " "
Grit	- 21 liters/1000 cu.meters sewage
Clarification (by activated sludge)	- 97%
Dry solids in raw sludge	- 22.6 tons/day

Screenings	- 1.56 cu. meters/day
Grit	- 5.2 liters/1000 cu. meters sewage
Clarification (by activated sludge)	- 80%
Dry solids in raw sludge	- 20.83 tons/day
Percent organic matter in raw sludge	- 71.1%
Gas production:	
Imhoff tanks	- 2,380 cu. meters/day
Separate digestion tanks	- 7,220 " " "
Gas used for power generation	- 5,300 " " "
Gas used for pumping effluent	- 2,460 " " "
Gas used for heating	- 3,870 " " "
Gas wasted	- 1,490 " " "

In order to save power and gas during the war, the activated sludge plant was not operated. The plant effluent is pumped to sewage farms.

GENERAL OBSERVATIONS

When the plant was visited only the primary treatment part was in operation. The flow being handled was only 20,000 cu. meters/day, and the gas production about 1500 cu. meters/day.

The machine house and aeration tanks suffered considerable bomb damage. (See Figures B-31-b to B-31-d incl.). Minor damages were also sustained by the final settling tanks. The plant grounds and tanks were poorly maintained.

ITEMS OF INTEREST

None.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-31

Name:	Berlin Wassmannsdorf Sewage Treatment Plant
Location;	Berlin
Date Visited:	July 26, 1945
Person Interviewed:	Mr. Thiele
Interviewed By:	Dr. Fischer

INFORMATION OBTAINED

This plant consists of mechanically raked bar screens, grit channels with travelling bucket elevators for grit removal, primary Imhoff tanks, spiral flow aeration tanks, Dortmund type plain secondary settling tanks, plain heated separate sludge digestion tanks, sludge drying beds, gas holders, gas engines for power generation, and gas compression equipment for supplying gas to automobiles. Large cylinders were used for transporting some of the compressed gas to central distribution points. (See Figure B-31-a).

The Imhoff tanks were constructed in the early 1930's, the activated sludge plant and power generation equipment added about 1935, and the gas compression equipment built during the war.

Capacities of the various units are:

Primary settling (Imhoff tanks)	- 6200	cu.meters
Aeration tanks	-15,000	" "
Final settling tanks	- 3576	" "
Digestion tanks:		
Imhoff	-15,300	" "
Separate digestion	-20,400	" "

Average flows, etc., for the year ending March 31, 1938, were:

Connected population	- 551,300	
Flow to primary treatment	- 83,000	cu.meters/day
Flow to secondary treatment	- 14,900	" " "

Percent organic matter raw sludge	- 77.3%
Gas production	- 7395 cu.meters/day
Gas used for power generation	- 4880 " " "
Gas used for heating	- 1605 " " "
Gas wasted	- 910 " " "

In order to save power and gas for auto use during the war, the activated sludge plant was not operated.

GENERAL OBSERVATIONS

When the plant was visited, only the primary treatment part was in operation. The flow being handled was 45,000 cu. meters/day. The total gas production was about 1500 cu. meters/day.

The plant suffered only slight bomb damage to one of the aeration tanks. One of the gasholders, however, was completely destroyed. (See Figure B-30-a). Plant maintenance (grounds) had obviously been neglected during the war, although practically all mechanical equipment was in good condition.

ITEMS OF INTEREST

None, other than the gas compressor system which is described more fully in another target report (Machinfabrik Esslingen).

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-32

Name: Nürnberg North Sewage Treatment Plant

Location: Nürnberg

Date Visited: July 31, 1945

Person Interviewed: Chief Eng. Detering

Interviewed By: Fischer, Lt.Col.Gilbert, Gorman, Lt.Pfreimer, Sheridan, Maj.Tatlock

INFORMATION OBTAINED

This plant consists of a storm water overflow chamber, a hand raked bar screen, two plain grit chambers, four primary settling tanks equipped with Mieder type sludge collectors, pneumatic sludge ejector, eight square sludge digesters arranged in two batteries of four each, sludge drying beds, and gas compression equipment.

Two digesters in each battery are primary digesters and are equipped with rotating disc sludge spreaders in order to evenly distribute incoming raw sludge over the area of these tanks. The other two tanks in each battery are used as secondary digesters, and communicate with the primary tanks via openings in the dividing walls near the top. Air is released from the raw sludge pumped over by the air ejectors in holding tank located over each tank battery. (See Figure B-32-a).

To supplement the internal digester heating coils, a preheater consisting of concentric pipes was installed in 1943, to heat the incoming raw sludge during the winter months. This unit is shown in Figure B-32-b.

The gas collection and compression system were of the conventional type, the capacity of the gas holder being 5000 cu. meters.

The sludge drying beds were surfaced with brick with sand filling the spaces between the brick. The purpose of this type of construction is to facilitate the removal of the dried sludge cake, and to avoid loss of sand in sludge removal.

In 1937, the plant treated sewage from a total population of 200,000. The per capita sewage flow was 200 liters per day. Daily gas production was 5000 cu.meters. Raw, digested and air dried sludge volumes were 250, 50 and 20 cu.meters per day respectively.

GENERAL OBSERVATIONS

Due to bomb damage, two of the settling tanks and the gas holder were out of operation. Due to breaks in sewers very little flow was coming down to the plant, and considerable settling of organic solids was occuring in the screen and grit chambers.

ITEMS OF INTEREST

Of interest to U.S., engineers should be the use of brick surfacing for the sludge drying beds. Also, of possible interest would be the use of pneumatic ejectors for the pumping of raw sludge, and rotating discs for distributing raw sludge in digesters. No data was available on the latter device but the engineer stated that comparative runs were made in which it was demonstrated that the sludge spreaders were of advantage.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-33

Name: Bad Nauheim Sewage Treatment Plant

Location: Bad Nauheim

Date Visited: July 13, 1945

Person Interviewed: Plant Operator

Interviewed By: Fischer, Lt.Col.Gilbert, Sheridan

INFORMATION OBTAINED

This plant consists of a plain bar screen, and grit chamber, Imhoff tanks, aeration tanks with Imhoff type paddles, and plain final settling tanks.

In order to save power, the aeration plant had not been operated since 1939. The normal (prewar) sewage flow was 3000 cu.meters/day from a contributing population of 10,000. The present flow is 4000 cu.meters/day from a population of 25,000. The increase in population is due to the large number of wounded German soldiers in local hospitals.

Present gas production is 180 cu.meters/day. The gas is fed into the city gas mains.

No analytical data showing plant results were available.

GENERAL OBSERVATIONS

The flow compartments of the Imhoff tanks were covered with a thick scum layer. According to the operator, this was due to the excessive accumulation of sludge in the digestion chambers. Lack of manpower to clean sludge beds, etc., was said to prevent more frequent sludge withdrawal and proper plant maintenance. The plant sustained no damage due to bomb or shell fire.

ITEMS OF INTEREST

None.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-34

Name: Munich Sewage Treatment Plant

Location: Munich

Date Visited: August 2, 1945

Person Interviewed: Chief Engineer Buckner

Interviewed By: Lt.Col.Gilbert, Lt.Pfreimer, Maj.Tatlock

INFORMATION OBTAINED

The City of Munich has one sewage treatment plant built in 1932, on the Isar River. The present population of Munich is 520,000 with 480,000 connected to the sewers. The flow from this population is approximately 3 cbm/sec of which 2 cbm/sec is treated, the rest being bypassed direct to the river. During storm flows all flows over 8 cbm/sec are bypassed.

The plant consists of the following units: (a) 2 Gièger vertical mechanical cleaned bar racks each of which are 5 meters wide with 7 mm clear opening. The racks are cleaned about every 2 hours by a vertically moving plate which passes over the bars. (b) 2 hand cleaned grit chambers, which are provided with a bucket elevator to remove and place the grit in an elevated hopper. No effort is made to wash the grit as it is used to cover the screenings from the bar screen which have been deposited in a remote area. The velocity thru the chambers is about 30 cm/sec. (c) 16 settling tanks are modified Imhoff type called Dyckerhoff and Widmann tanks. They provide for sludge digestion, gas collection and a settling period of 71 minutes with a velocity of 5mm/sec. (d) 330,000 sq. meters of fish ponds, which receive the effluent from the sewage plant. In these privately operated ponds the effluent is diluted with 3 times its volume river water. Each 10,000 sq. meters of pond is capable of supporting 500 kg of fish life and provides a biological treatment for the sewage before its discharge into the Isar River. (e) The digested sludge is withdrawn by gravity into a common well from which it is ejected by air to the sludge drying beds in the summer and to lagoons in the winter. Sludge is taken from the beds by means of a bucket elevator carried on a traveling crane. The sludge is crushed and discharged to trucks which carry it to nearby farms to be used as fertilizer.

(f) During normal peacetimes 300 tons of fat per year were reclaimed from this sewage plant. However, due to the decrease in the amount of fat coming to the plant and the scarcity of labor and equipment the fat was not reclaimed during the war. (g) The sewage gas is measured and pumped into the city gas supply lines.

GENERAL OBSERVATIONS

While the use of sewage effluent to provide organic matter for fish life has been satisfactory for Munich and other cities, a contemplated new plant will have biological filters because (a) Lack of sufficient land for the ponds, and (b) Biological action in the ponds ceases in the winter.

The mechanical removing of dried sludge from the sand beds not only saves labor but enables the operator to refill the beds oftener due to the short cleaning period required.

ITEMS OF INTEREST

None.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-35

<u>Name</u>: Stuttgart Sewage Treatment Plant

<u>Location</u>: Stuttgart

<u>Date Visited</u>: July 27, 1945

<u>Persons Interviewed</u>: Paul Reus, city engineer, W.Sohler, chief engineer, Sewer Division

<u>Interviewed By</u>: Lt.Col.Gilbert, Lt.Pfreimer, Dr.Sheridan

INFORMATION OBTAINED

The treatment of sewage is a most comprehensive one and includes screening, grit removal and use, settlement tanks of various types, trickling filters, sludge processing of several kinds, gas collection and garbage disposal. Following are details:

(1) <u>Screening</u>: The sewage from Stuttgart first passes thru a Geiger mechanically cleaned bar screen. The screenings are ground in a Passavant shredder and returned to the sewage in order not to lose any organic matter which could be used to generate gas.

(2) <u>Grit Removal</u>: The sewage next passes thru a hopper bottom grit chamber before entering an inverted siphon which carries the sewage under the Neckar River to the treatment plant. The grit is removed by means of a bucket elevator and washed in a standard Excelsior sand washer. (The type used in washing sand for slow sand filters and sand for commercial uses). The engineer stated that as sand is difficult to obtain in Stuttgart every effort must be made to reclaim it.

(3) <u>Primary Settling</u>: The first units were constructed in 1912, and additions made in later years so that settling units now consist of Neustadt tanks, Imhoff tanks, Stuttgart or Sohler tanks, and 4 rectangular mechanically cleaned settling tanks with a Mieder type collector designed by the city engineer and built by a local firm in 1936. The collector travels at a speed of 30 cm/sec when skimming and 5 to 10 cm/sec when collecting the sludge. One or two cleanings per day is sufficient.

(4) Digestion: Two separate heated digesters were built in 1936, and two more in 1938. Cork insulation was tried on the first tanks but as this peeled loose, a 5 cm thick air pocket with a 3 cm plastic cover was used on the 1938 tanks. This proved successful. The tanks are heated by vertical water pipes suspended from the roof and rotated at a speed of 80 cm/sec., to aid in heat distribution and prevent scum. (See Figures B-35-a and B-35-b). The water is heated to 40°C while the tanks are maintained at a 25°C temperature. The tanks are designed at 30 liters per capita, each having a capacity of 1500 cm. City gas is used to heat the tanks while the sewage gas is sent to the city gas works because of its high caloric value.

(5) Gas Utilization: The waste from a leather tannery having a pH value of 10.0 is received at this plant and in order to reduce this value so its sludge will digest, sewage gas as generated is passed through the tannery wastes. This removes the CO_2 from the gas and reduces the pH value of the tannery wastes to 7.0, thus accomplishing two objectives with one operation.

(6) Sludge Disposal: Raw sludge and partially digested sludge of 85% H_2O is purchased by a private company. These sludges are mixed with peat from western Germany in the ratio of 1 sludge to 4 peat with a little lime added to raise the pH value. This wet mixture is sold as fertilizer to farmers for 12 marks/cu.m. Sludge from the digesters is dried on open sand beds and removed by means of a mechanical cleaner carried on a traveling crane.

A plant is also under construction whereby the digested sludge will be mixed with raw garbage. The product is processed and placed in open sand beds for 2 or 3 months. The mixture will then be removed and used for fertilizer.

(7) Filters: Standard design trickling filters are in use, the beds being 1.75 m deep. These beds are rectangular in shape and are dosed by means of rotary distributors. The spaces between the areas covered by the rotary distributors are sprayed with fixed nozzles.

A portion of the beds is now being reconverted into special high rate filters. Rotary distributors are used with a number of smaller rotary distributors for covering the areas between the larger units. The contemplated dosage will be 9 cbm/cbm of filter material. Some experiments have been made but no results are available as the lack of materials has prohibited the completion of this work. (See Figure B-35-8).

In order to provide air throughout the entire filters horizontal open joint tile is laid at one meter intervals at one-half the depth of the beds.

(8) Final Settling: The filter effluent is clarified in hopper bottom center feed vertical flow settling tanks.

GENERAL OBSERVATIONS

(1) Rotating heating coils appear to be sufficient to produce a good digested sludge in the tanks.

(2) Partially digested sludge provides moisture and biological action for peat moss, thus giving it a fertilizing as well as a humus value.

(3) Full utilization of organic matter for gas production and fertilizer is being practiced.

(4) Interest is being shown in high rate filters with rectangular beds being used to save space.

(5) Washing of sewage grit to reclaim sand is practical where sand is scarce.

(6) Due to a higher caloric value sewage gas is superior to coal gas.

(7) The removal of CO_2 from sewage gas by means of tannery wastes proved practical in this plant.

ITEMS OF INTEREST

Of particular interest to U.S. engineers should be the arrangement of the trickling filters, the washing of grit to recover sand, and the use of digester gas to reduce the pH value of highly alkaline trade waste.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-36

<u>Name</u>: City of Mannheim Sewage Treatment Plant

<u>Location</u>: Mannheim

<u>Date Visited</u>: July 24, 1945

<u>Person Interviewed</u>: Karl Fritsch, city engineer

<u>Interviewed By</u>: Lt.Col.Gilbert, Lt.Pfreimer, Dr.Sheridan

INFORMATION OBTAINED

The existing sewage plant at Mannheim was constructed in 1906. It consists of primary settling and is now in poor condition. This plant was not visited as city engineer Fritsch discussed a new plant which is being planned.

A report on the proposed new plant was made in November 1944, to the city engineer by Dr. Imhoff. An outline of the plant follows to indicate present design practice in Germany

The sewage effluent will be discharged into the Rhine River after primary treatment. Space has been provided for activated sludge secondary treatment but construction of this treatment step is not contemplated at this time.

The plant will consist of the following units:

(a) A Geiger mechanically cleaned screen and a Passavant shredder with its discharge point after the grit chamber, in order to prevent the settlement of these ground screenings in the grit chamber.

(b) A Geiger tangential flow grit chamber, designed for 30 cm/sec velocity and provided with an air lift to wash the grit in the chamber and to elevate it to a storage hopper.

(c) Two primary settling tanks, rectangular in shape and providing for 1-1/2 hours detention. The tanks will be equipped with one Geiger Mieder type sludge and scum collector.

(d) Four Bamag digesters in pairs, only the primary digester of each pair being heated. The tank walls will be provided with cork or other insulation to reduce heat losses. Impellers will be installed at the sludge surface to break up the floating scum. The design capacity is 15 liters per person in each tank, makihg a total design basis of 60 liters per capita. The digesters will be heated with coke in order to conserve the sewage gas which will be compressed for auto fuel or pumped to the city gas mains.

(e) The sludge drying beds will provide a drying area of 0.05 sq. meters per capita. They will be equipped with a portable belt conveyor to aid in the removal of the sludge from the beds.

(f) The dried sludge will be sold to farmers for fertilizer after being mixed with composted garbage from an existing sanitary garbage fill. Experiments will be made on the mixing of fresh garbage with the dried sludge and the use of the mixture as a fertilizer.

Description of the mechanical equipment listed above is given in the target report on the respective manufacturers.

GENERAL OBSERVATIONS

The proposed plant is designed along the lines of a modern primary treatment plant in America. The equipment varies somewhat from American design and is described under other target reports herein.

ITEMS OF INTEREST

None of special interest to U.S. engineers.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-37

Name: Tubingen Sewage Treatment Plant

Location: Tubingen

Date Visited: August 8, 1945

Person Interviewed: Superintendent

Interviewed By: Lt.Col.Gilbert, Lt.Pfreimer, Maj.Tatlock

INFORMATION OBTAINED

The normal population of Tubingen is 22,000 while the present population is 28,000, due to the presence of displaced persons. The town is only partly sewered so that the plant serves only 8000 people. The average gas yield is 200 to 230 cm/day.

The plant consists of two pairs of Imhoff tanks, one being built in 1927 of the conventional design and the other in 1933 of a modified design. The 1933 tanks are constructed so that the influent enters the tank at a point about 12 feet from the front end in a diredtion away from the effluent end. The flow must, therefore, reverse itself to reach the effluent weir

There are four heated digestion tanks which are provided with gas collection. The collected gas is compressed at the plant for use in automobiles. In order to have the maximum gas available for this purpose, the gas fired hot water heaters from the digestion tanks were abandoned in 1940 and coal fired boilers substituted. The gas is sold for 4 marks per 10 cu.meters while gasoline sells for 0.42 marks per liter. It is estimated that 10 cu.meters of compressed sewage gas is equal to 12 to 13 liters of gasoline. (See target report on Maschinenfabrik-Esslingen for a description of a similar gas compression plant). This gas compression plant with a capacity of 80 cm/hr., cost about 85,000 marks to construct in 1940.

GENERAL OBSERVATIONS

It appears that the production of automobile fuel is of primary interest in the operation of this plant.

The Imhoff tanks, providing for reversal of flow within the tanks, appeared to give excellent removal of suspended solids.

ITEMS OF INTEREST

None, other than the gas compression equipment.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-38

<u>Name</u>: Ludwigshafen Sewage Treatment Plant

<u>Location</u>: Ludwigshafen

<u>Date Visited</u>: July 24, 1945

<u>Person Interviewed</u>: Superintendent

<u>Interviewed By</u>: Lt.Col.Gilbert, Lt.Pfreimer, Dr.Sheridan

INFORMATION OBTAINED

The City of Ludwigshafen has a normal population of 145,000 which has been reduced to 80,000 because of the war. The sewage plant was designed and built in 1923 for a population of 150,000.

The plant consists of the following units:

(a) Hand cleaned bar screen
(b) A grit sump which is cleaned by lowering a bucket elevator which is pivoted about its head shaft. The grit is not washed and is only used for fill.
(c) Two Reinsch-Würl screens each capable of handling the entire sewage flow. One screen is shut down each year and cleaned and repaired. Neither screen is now in operation due to the lack of spare parts and because there is no transportation for the screenings. The screenings were normally carried away to farms where they were composted with the barnyard manure and then used for fertilizer.
(d) Two low lift pumps which elevate the sewage to the Rhine River in times of flood flow. The town also has two other plants which were not visited. They consist of primary treatment utilizing Neustadt tanks that were built in 1929.

GENERAL OBSERVATIONS

The use of the bucket type elevator employed to remove the grit from the grit chambers was interesting. The grit was not clean. It is questionable whether the chamber was very efficient.

The composting of fine screenings with barnyard manure to serve as fertilizer is another German practice to conserve all organic matter.

ITEMS OF INTEREST

The type of grit elevator used was novel but not of particular interest to U.S. engineers.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. B-39

Name: Bad Soden Sewage Treatment Plant

Location: Bad Soden

Date Visited: July 13, 1945

Persons Interviewed: None

Interviewed By: Fischer, Lt.Col.Gilbert, Sheridan

INFORMATION OBTAINED

The sewage plant at Bad Soden was built in two units. The first consists of center feed vertical flow Kramer-Kusch tanks with a trickling filter equipped with a distributor as shown in Figures B-39-a and B-39-b. The sewage enters the filter at the center and is discharged from a horizontal pipe through vertical outlets. The sewage falls on a water wheel the length of which is equal to the radius of the tank, causing the distributor to rotate and distribute the sewage over the surface of the filter bed. The distributor is supported at the center of the tank by the riser pipe and at the periphery by a wheel and steel track on the filter wall.

The second or new unit is a conventional Imhoff plant with a standard rotary distributor trickling filter.

GENERAL OBSERVATIONS

The water wheel distributor was broken and out of operation. The fact that the new plant used the standard rotary distributor indicates that the water wheel distributor is not a practical item of equipment.

ITEMS OF INTEREST

None.

NEW PROCESSES OR EQUIPMENT

None.

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REPORT ON SEWAGE TREATMENT IN GERMANY

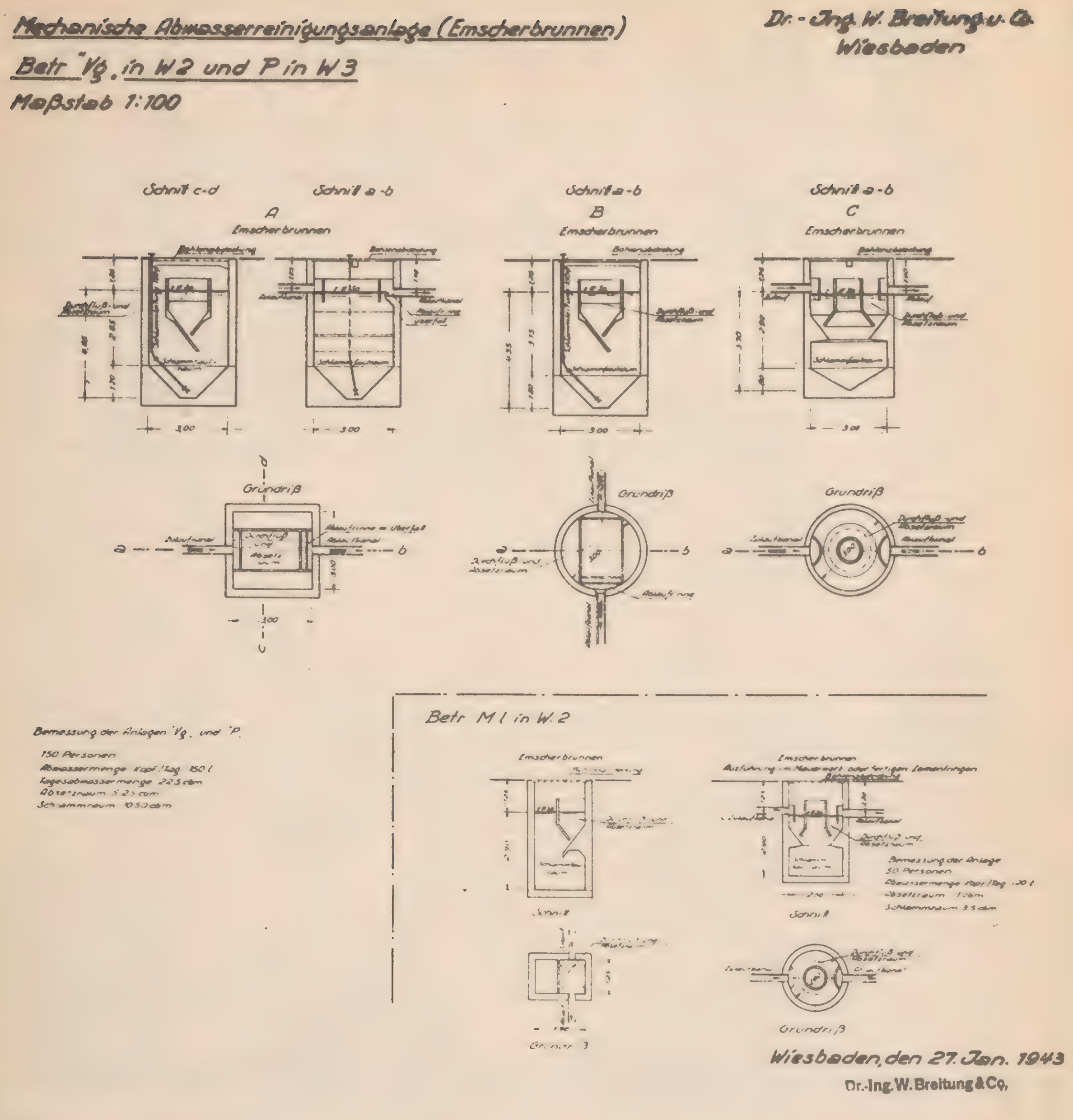

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Fig. B-2-a, Imhoff Tank Designs - 50 and 150 persons

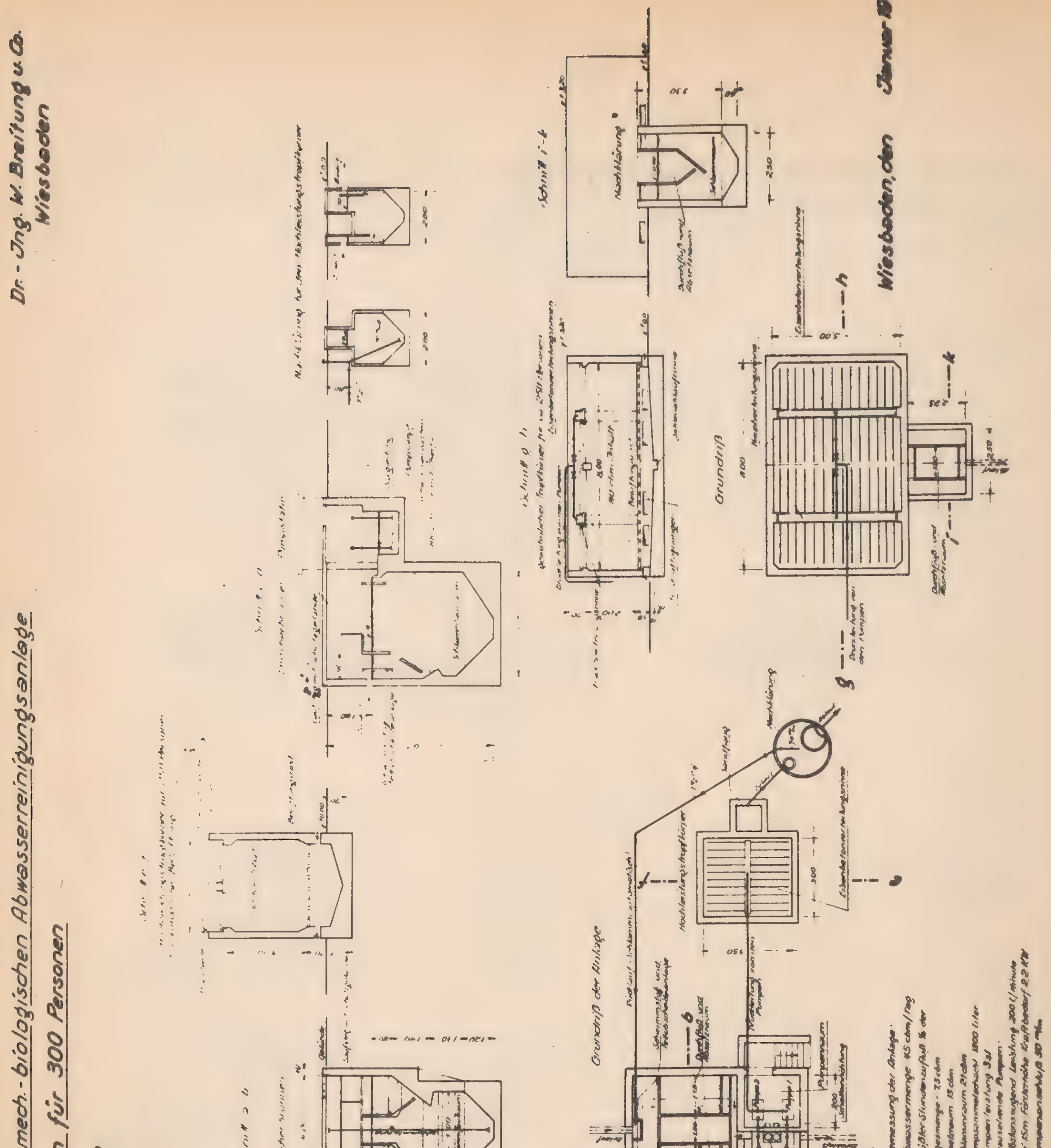


Fig. B-2-b, Imhoff Tank and High Rate Filter Plant - 300 persons

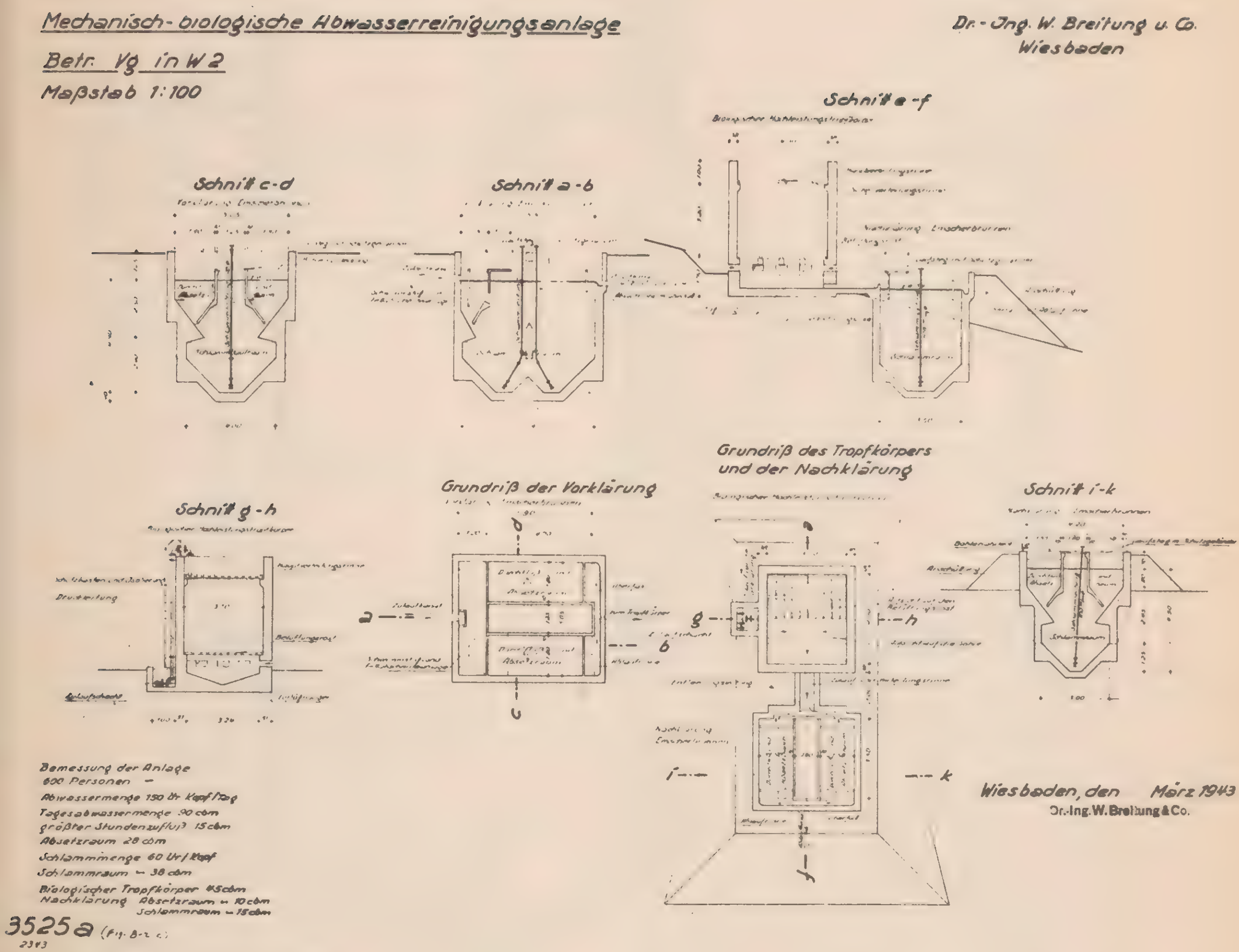


Fig. B-2-c, Imhoff Tank and High Rate Filter Plant - 600 persons

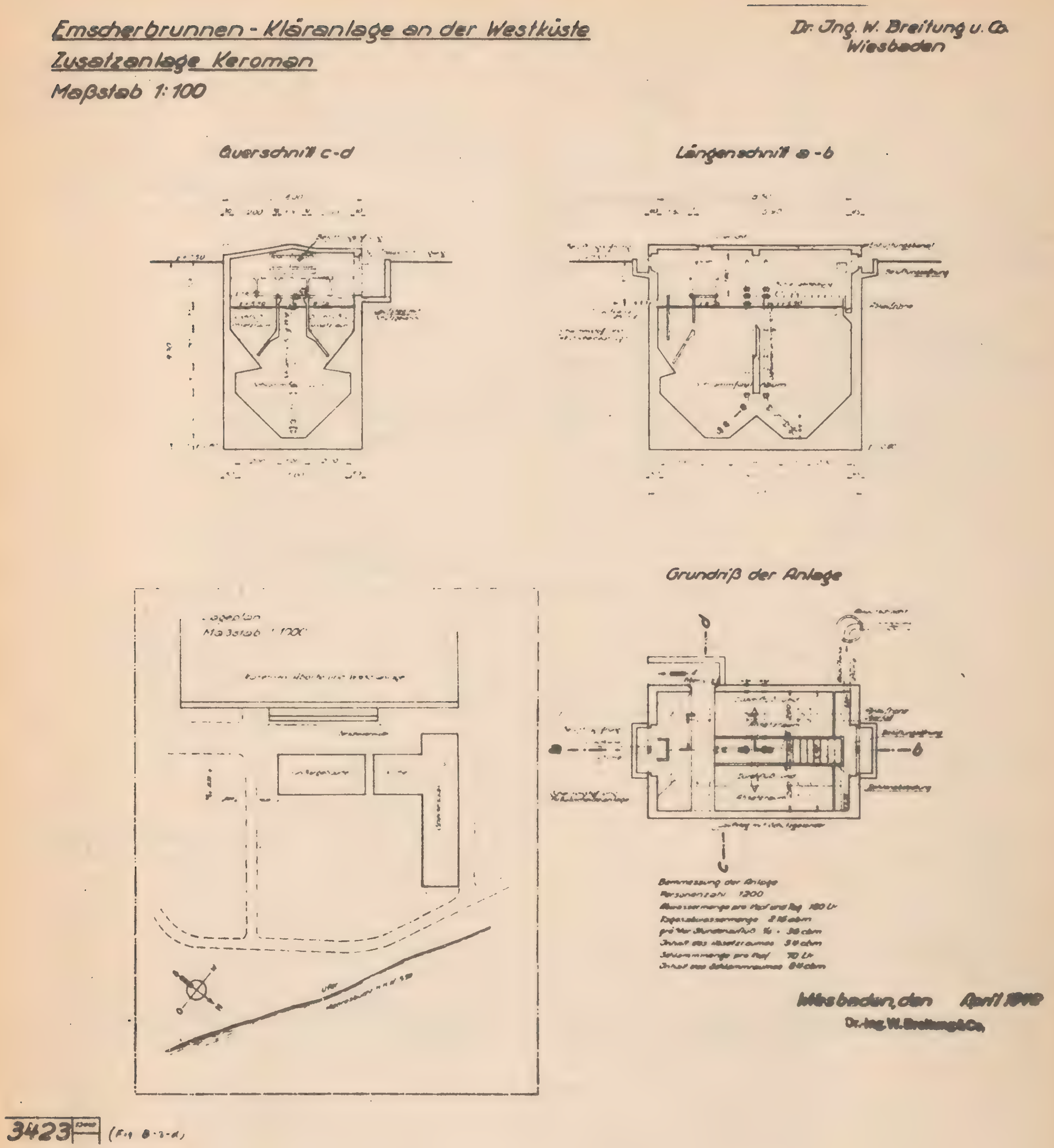


Fig. B-2-d, Imhoff Tank Design - 1200 persons

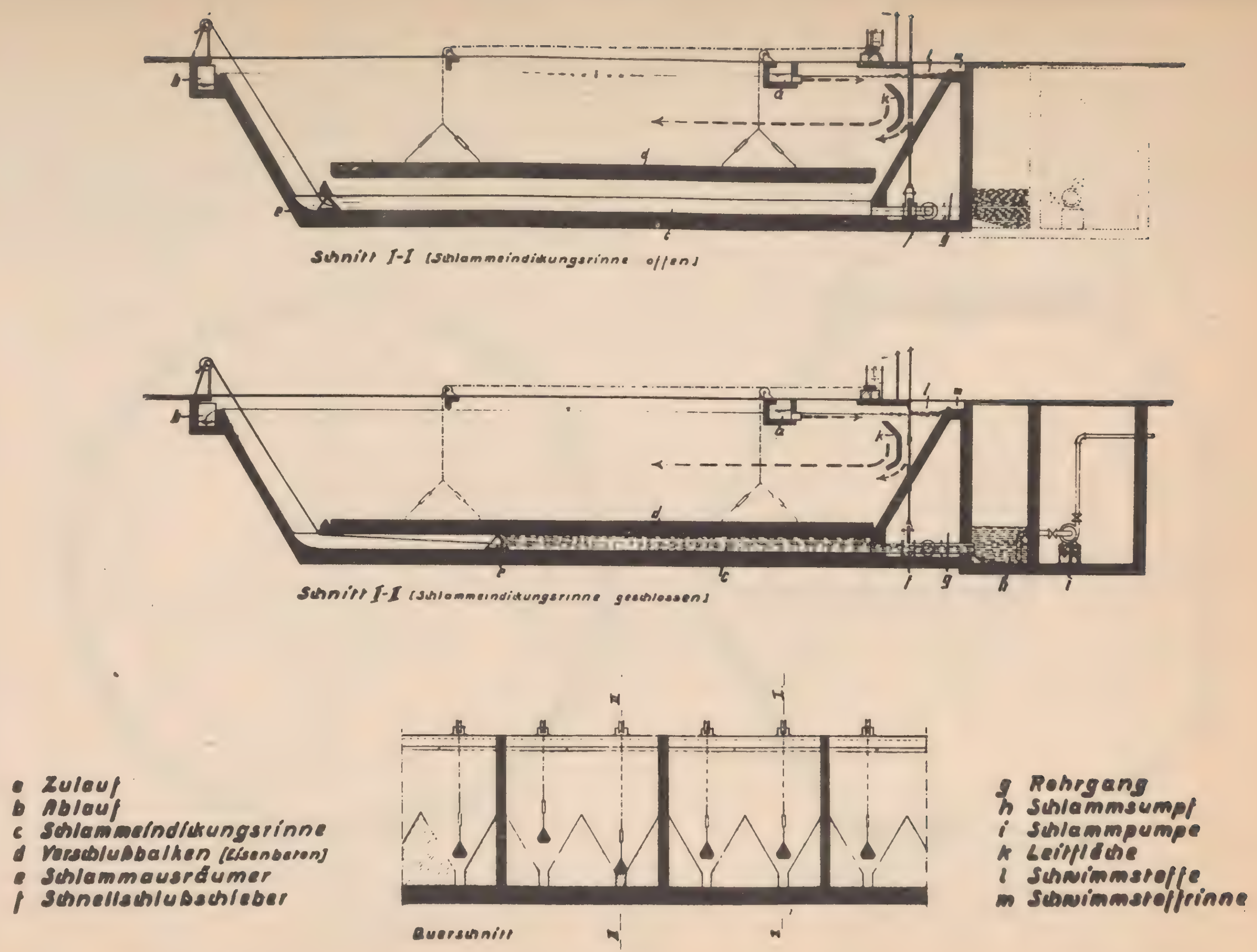


Fig. B-5-a, Neustadt Tank Design

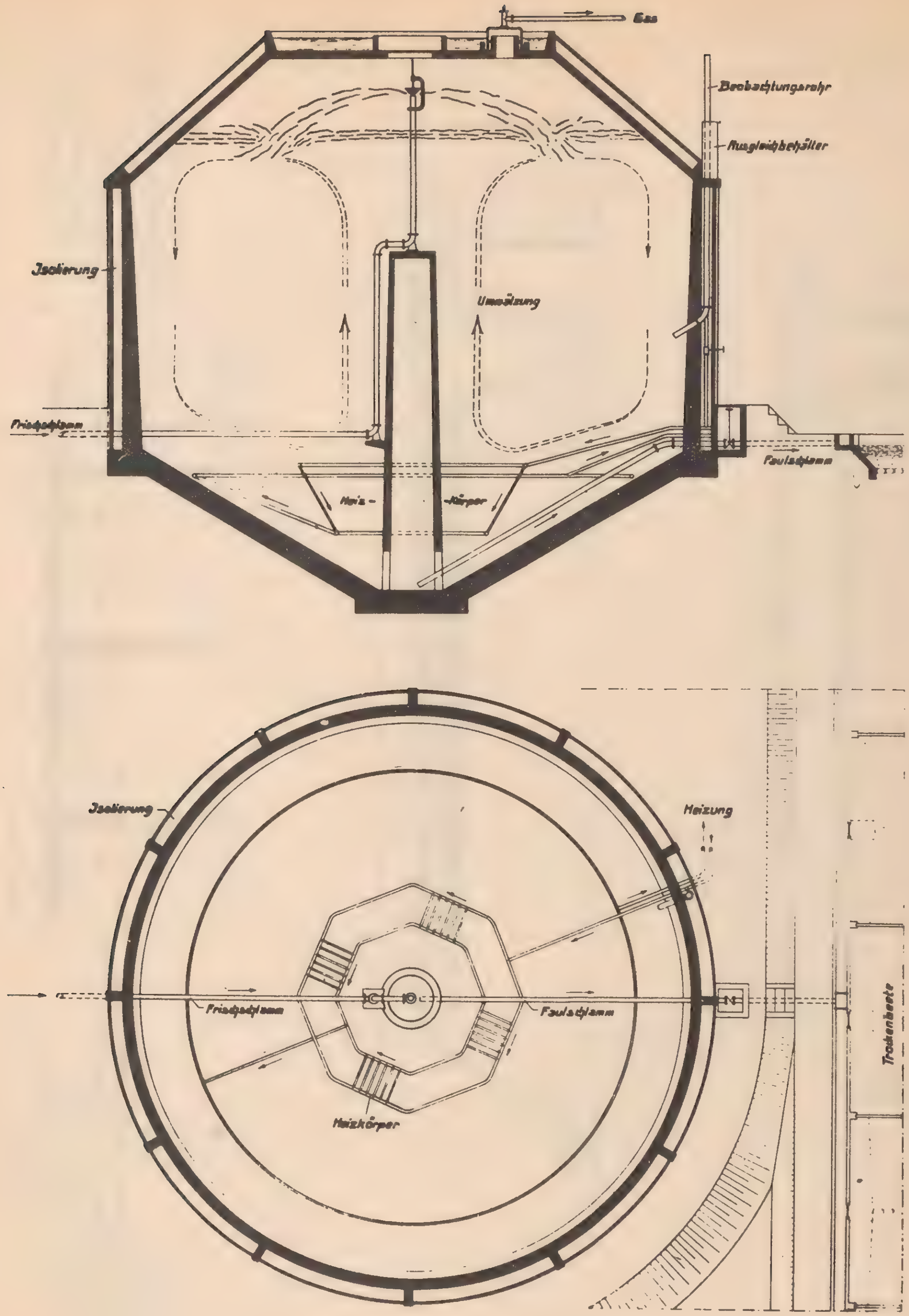


Fig. B-5-b, Digester Design, Steuer

Fig. B-8-a, Emscher District. Location Sewage Treatment and Phenol Recovery Plants

Fig. B-8-b, Lippe District. Location Sewage Treatment Plants

Fig. B-10-a, Niers District.
Hüls Plant

Fig. B-10-b, Niers District.
Golden Plant

Fig. B-10-c, Niers District. Kempen Plant

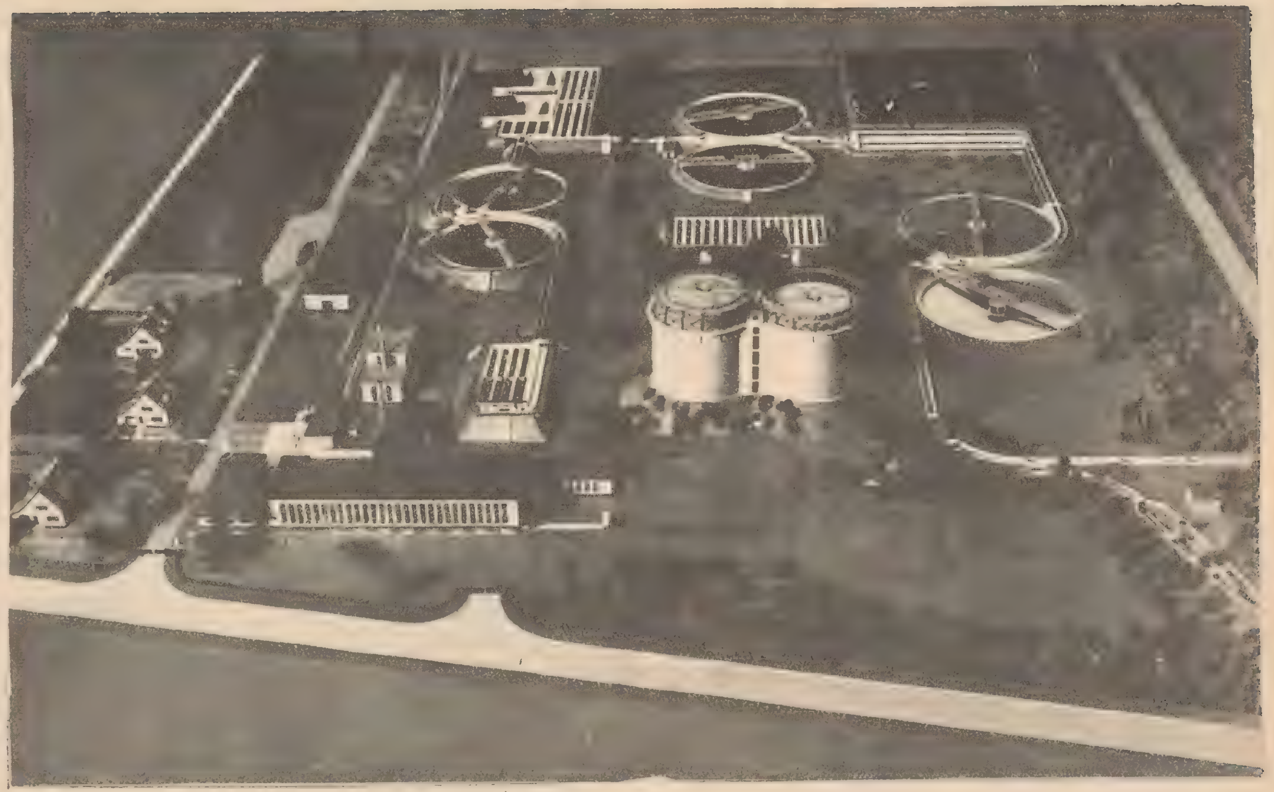


Fig. B-10-d, Niers District Plant No.1. Model General Plan

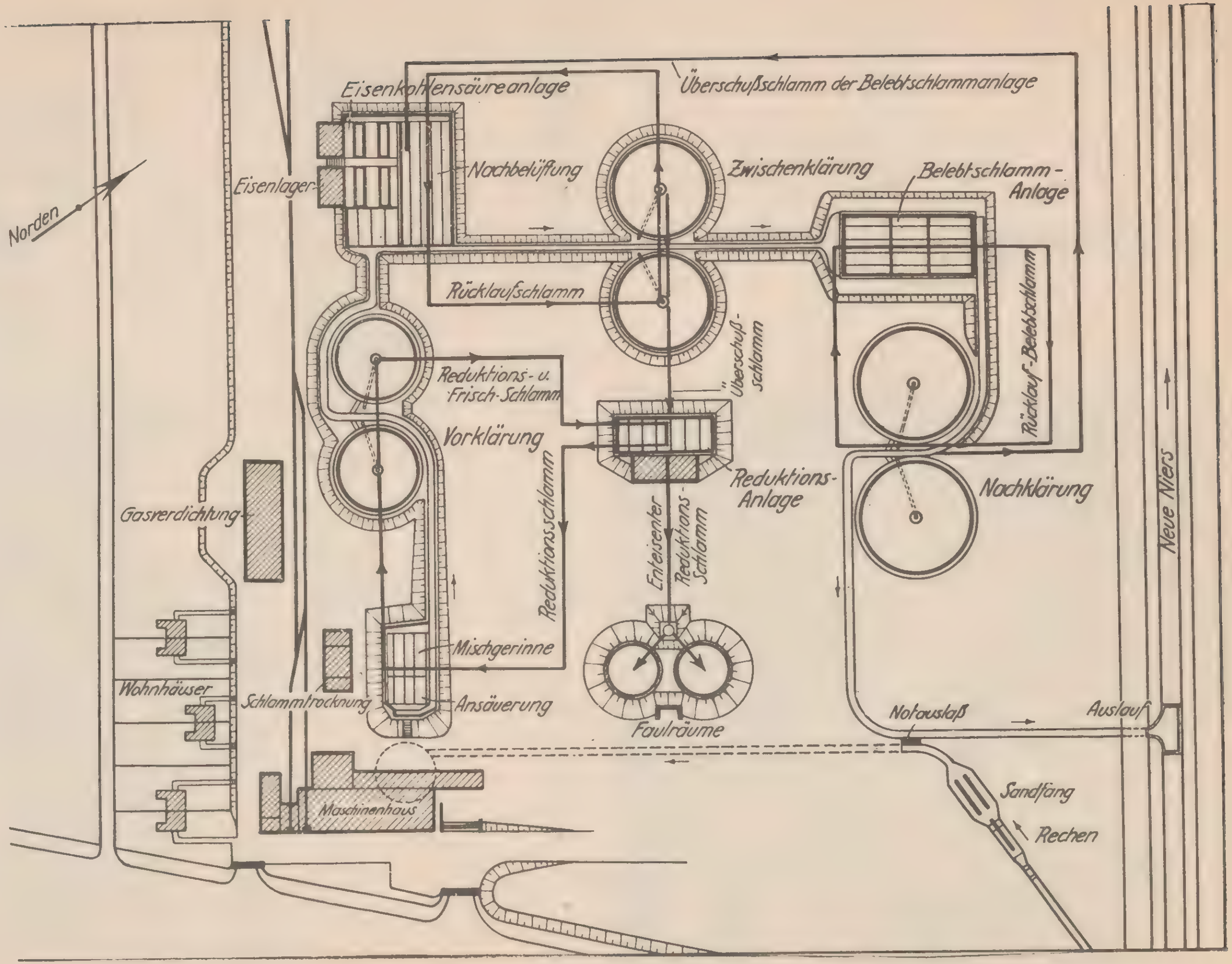


Fig. B-10-e, Niers District Plant No.1. Flow Sheet.

Fig. B-10-f, Niers District Plant No.1. Bar Screens. Digesters in Background

Fig. B-10-g, Niers District Plant No.1. Grit Chambers with Gritwasher

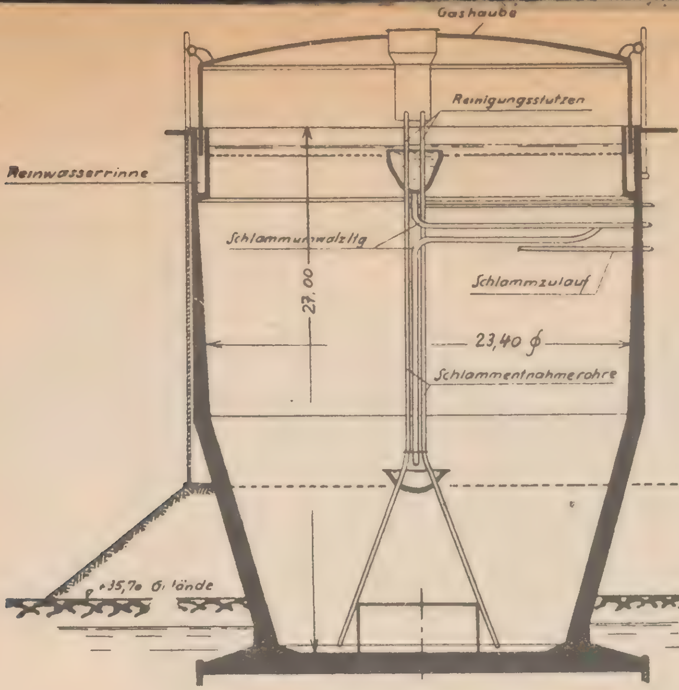


Fig. B-10-h, Niers District Plant No.1. Digestion Tank

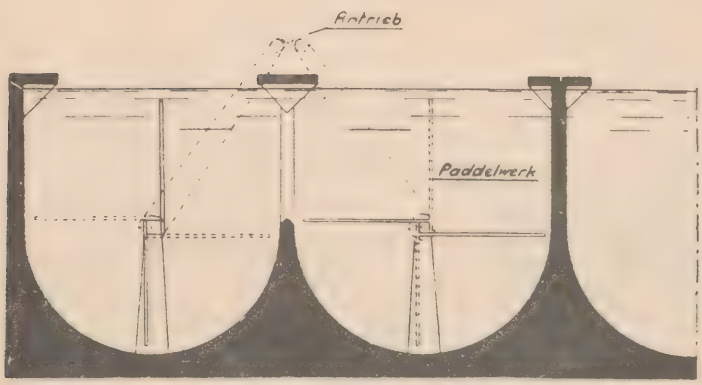


Fig. B-10-i, Niers District Plant No.1. Mixing Tank

Fig. B-10-j, Niers District Plant No.1. Settling Tank

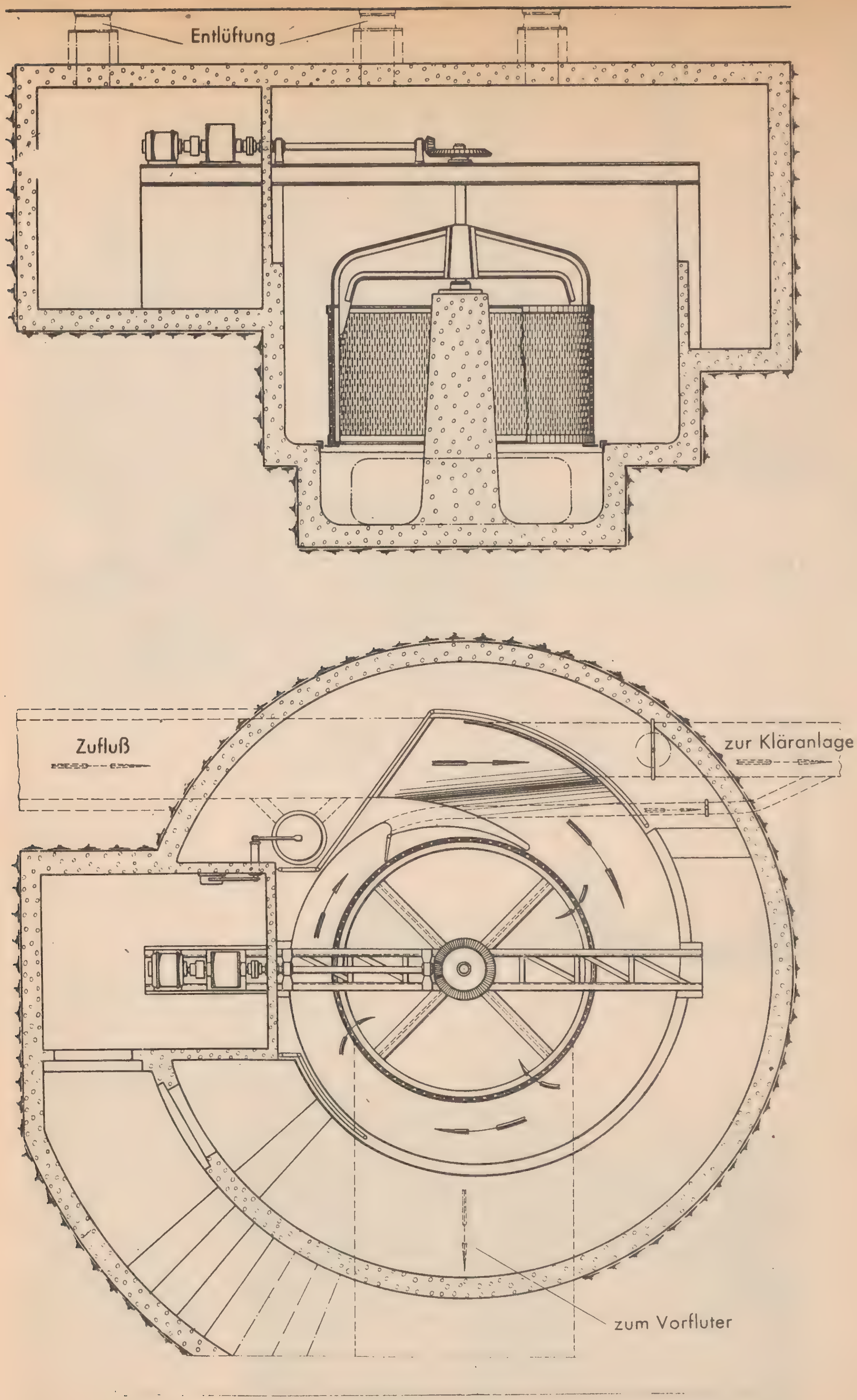


Fig. B-11-a, Passavant Centri-Screen

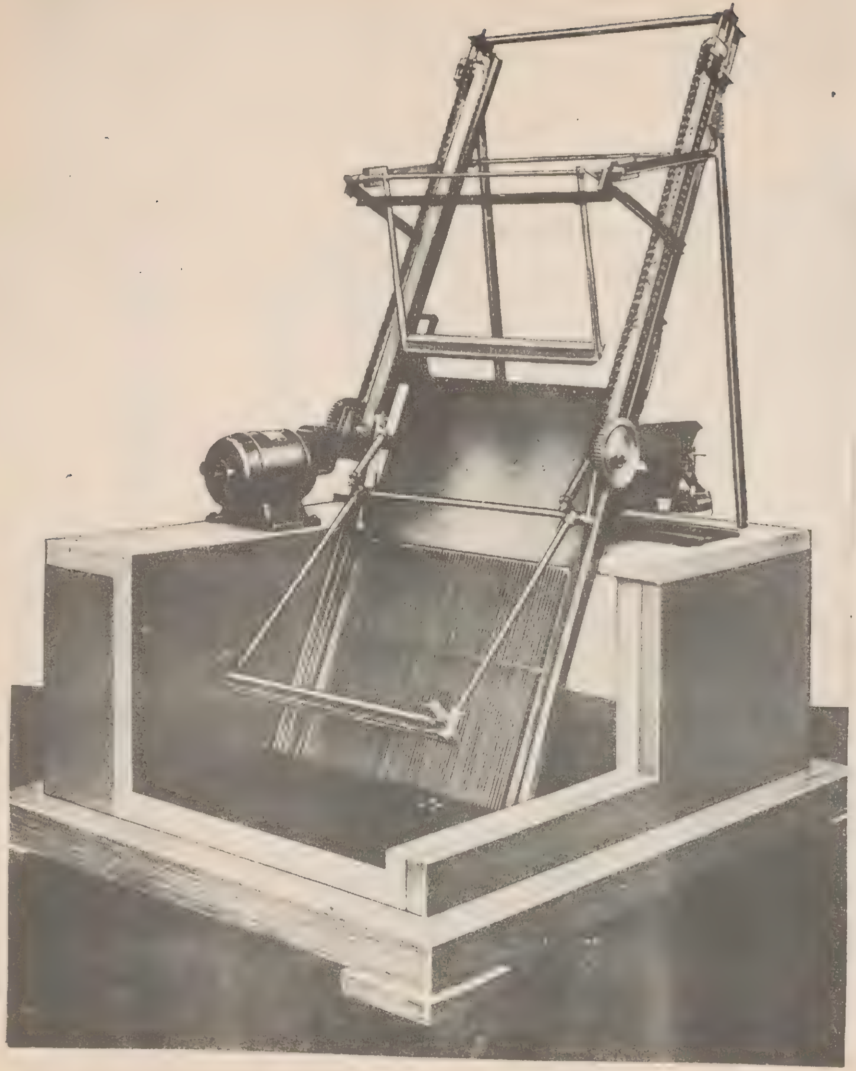


Fig. B-11-b, Passavant Sewage Screen

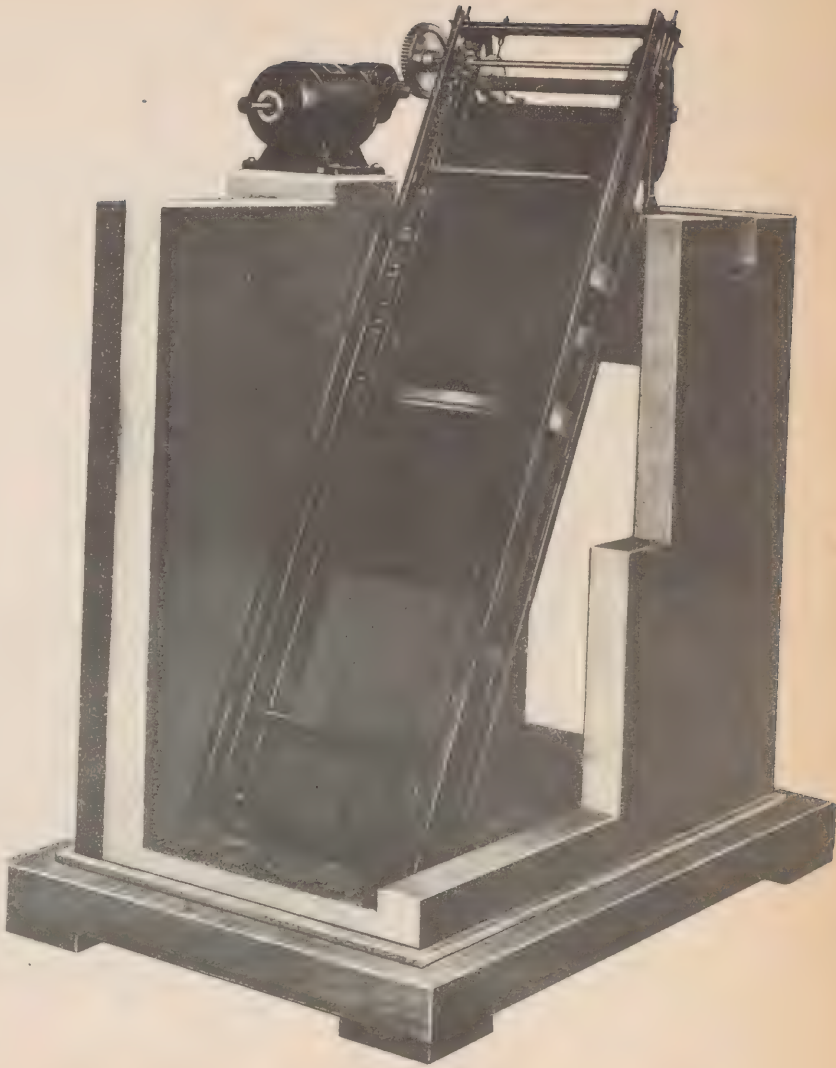


Fig. B-11-c, Passavant Water Screen

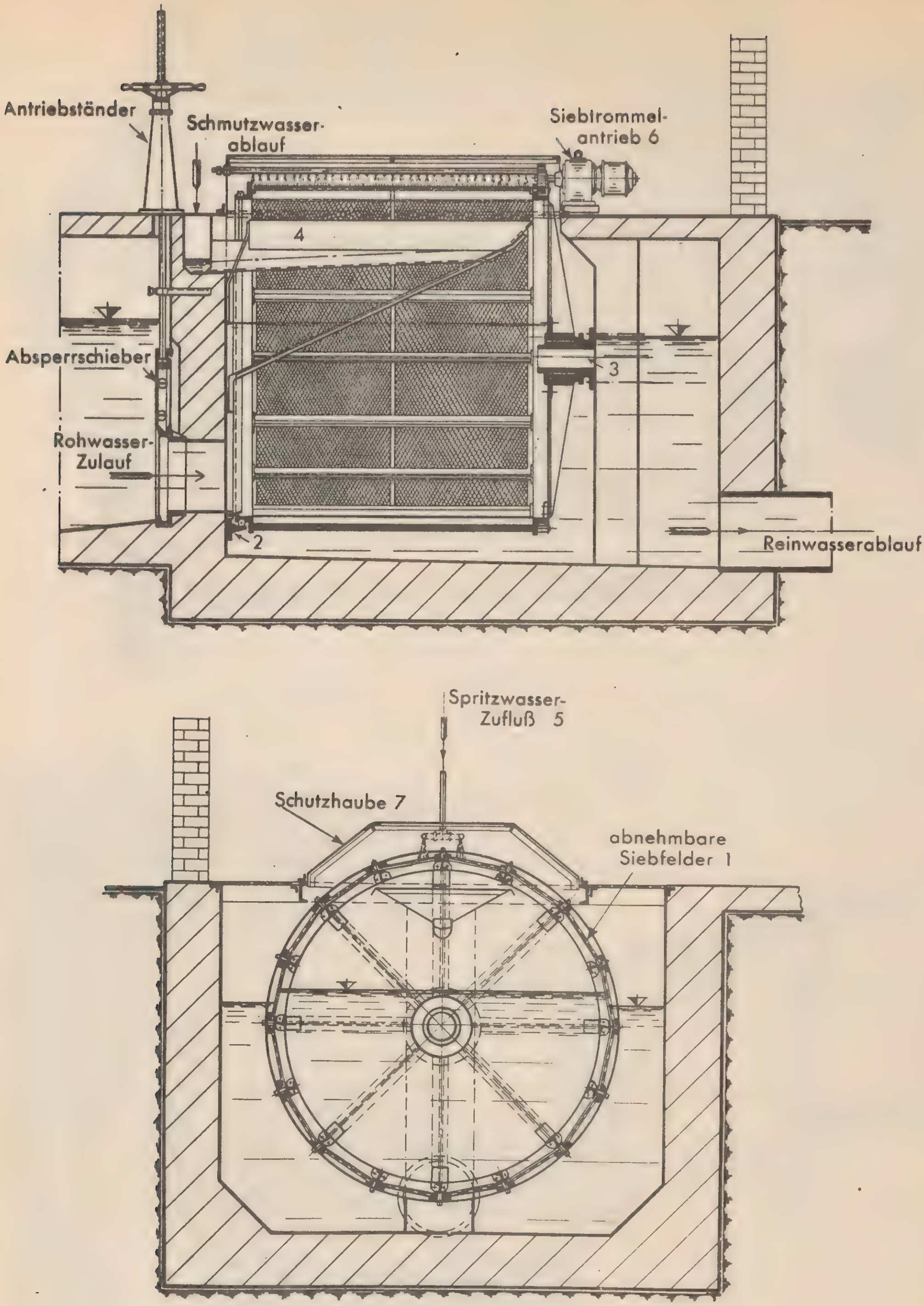


Fig. B-11-d, Passavant Fine Screen (water)

Fig. B-11-e, Passavant Rectangular Settling Tank

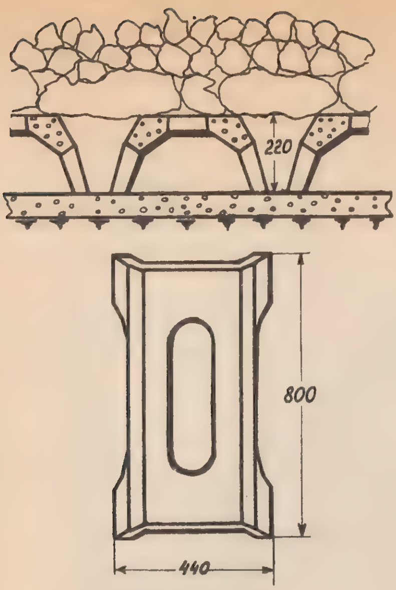


Bild 1

Belüftungsstein

Gewicht ca. 40,0 kg
Kennziffergewicht 0,5 „

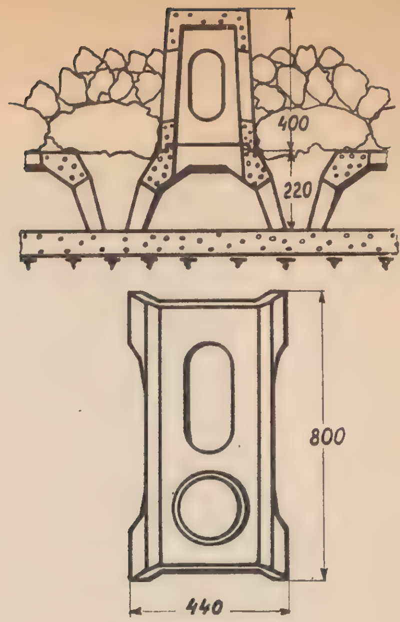


Bild 2

Belüftungsstein mit Pilz

Gewicht ca. 60,0 kg
Kennziffergewicht 0,8 „

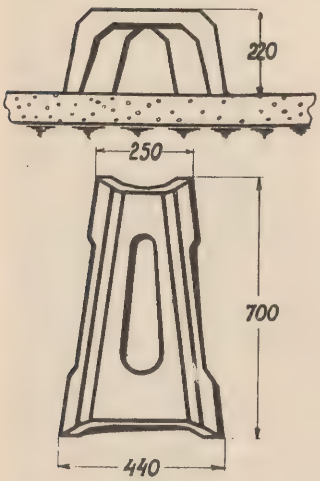


Bild 3

Zwickelstein

Gewicht ca. 38,0 kg
Kennziffergewicht 0,5 „

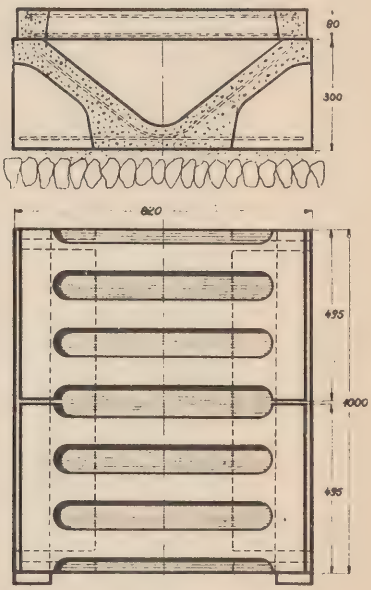
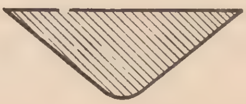


Bild 4

Sohlstein mit -Platte

Gewicht des Sohlsteines ca. 200,0 kg
Kennziffergewicht 0,5 „
Gewicht der Sohlplatte ca. 50,0 „
Kennziffergewicht 1,5 „

Durchgangsquerschnitt = 0,05 m²
zu Bild 1 und 2



Durchgangsquerschnitt = 0,08 m²
zu Bild 4

Fig. B-11-f, Passavant Filter Underdrains

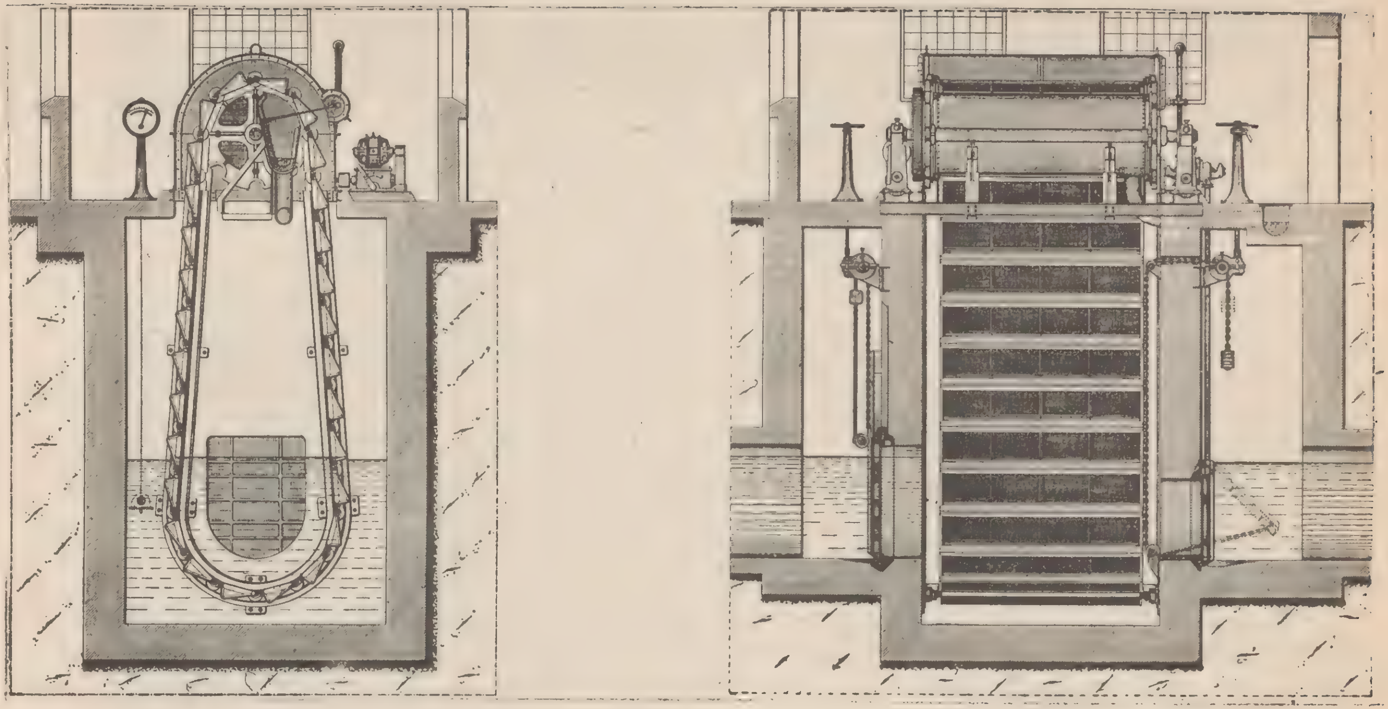


Fig. B-12-a, Geiger Water Intake Screen

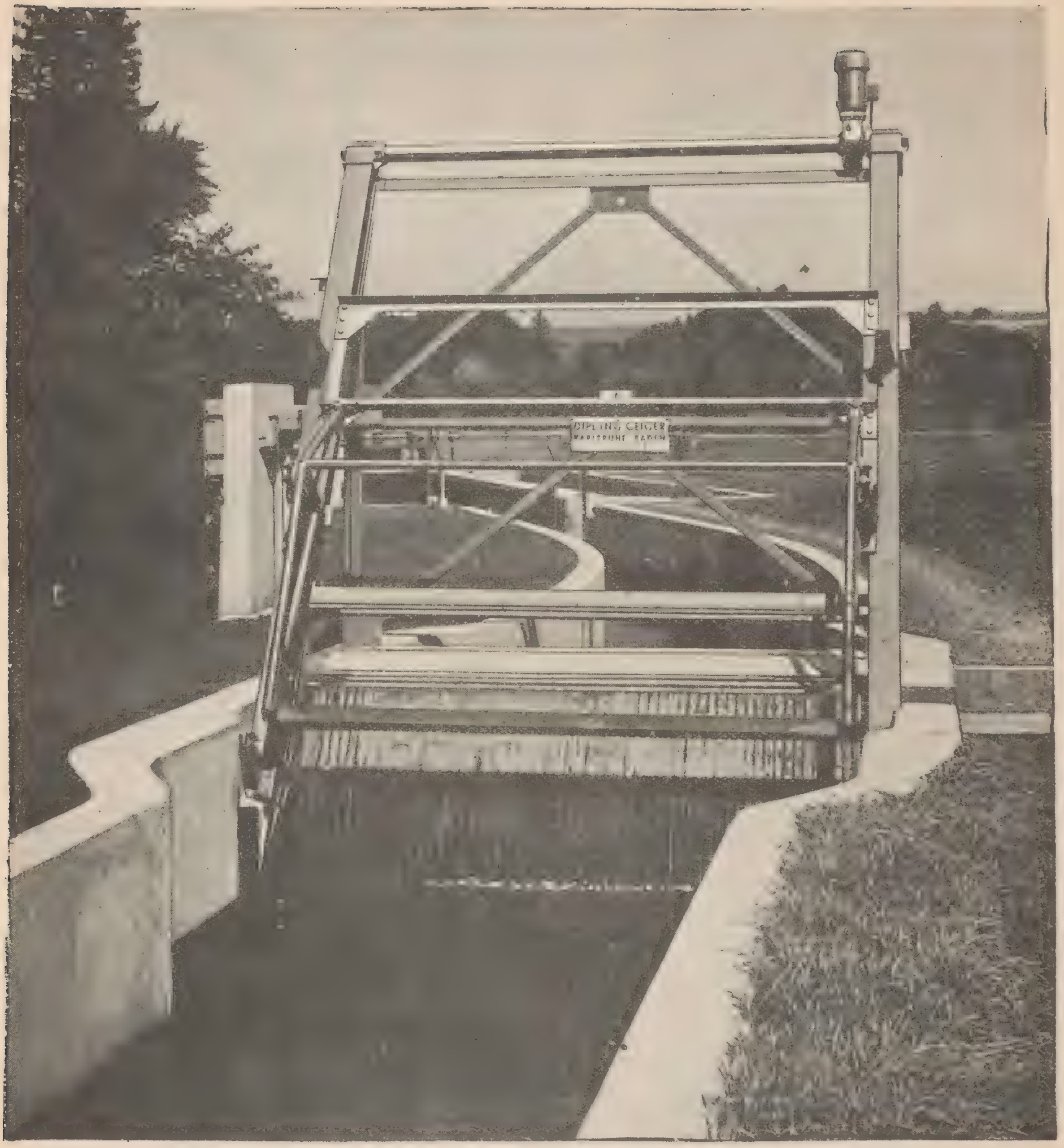


Fig. B-14-a, Geiger Bar Screen - Large Plants

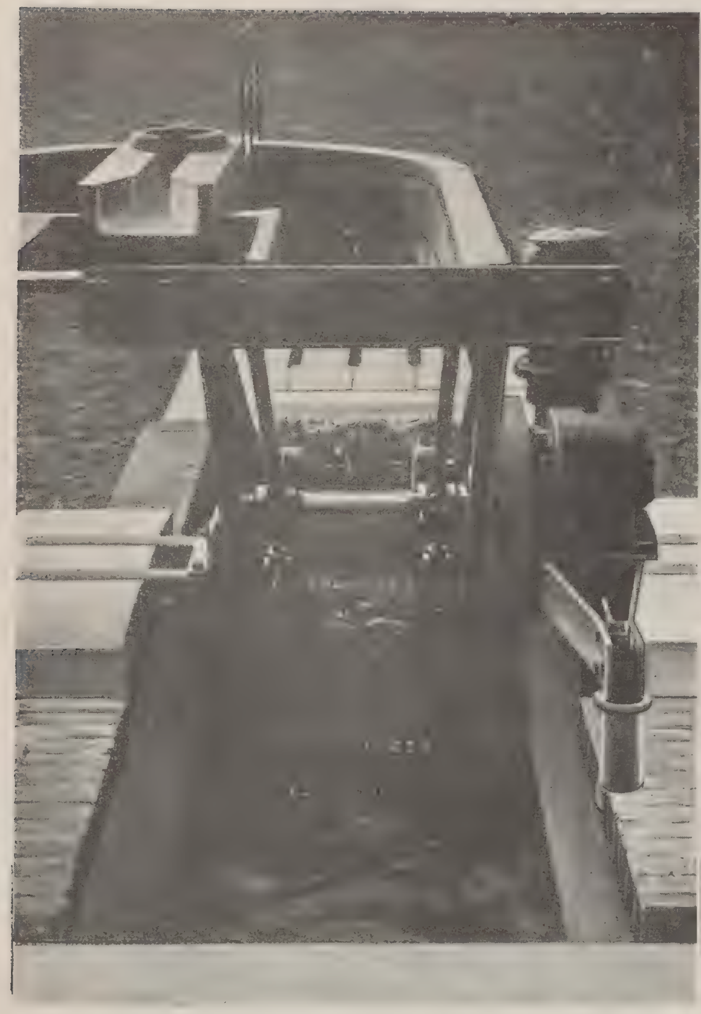


Fig. B-14-b, Geiger Bar Screen - Small Plants

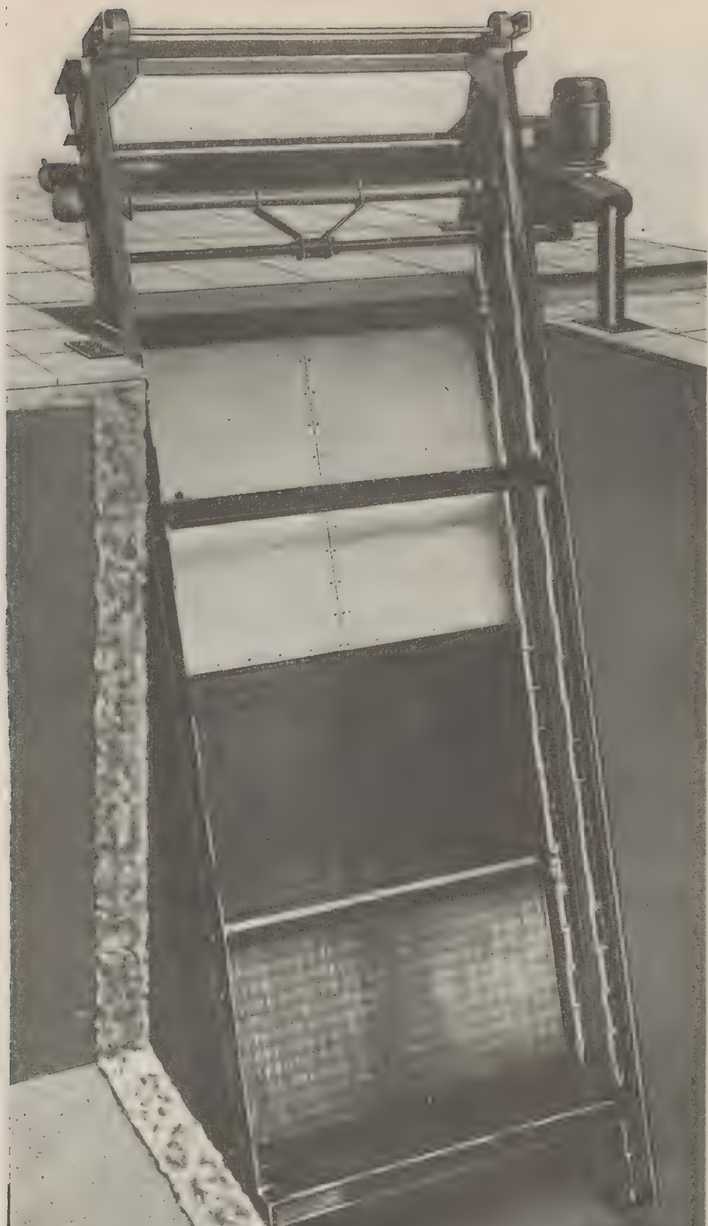


Fig. B-14-c, Geiger Water Screen

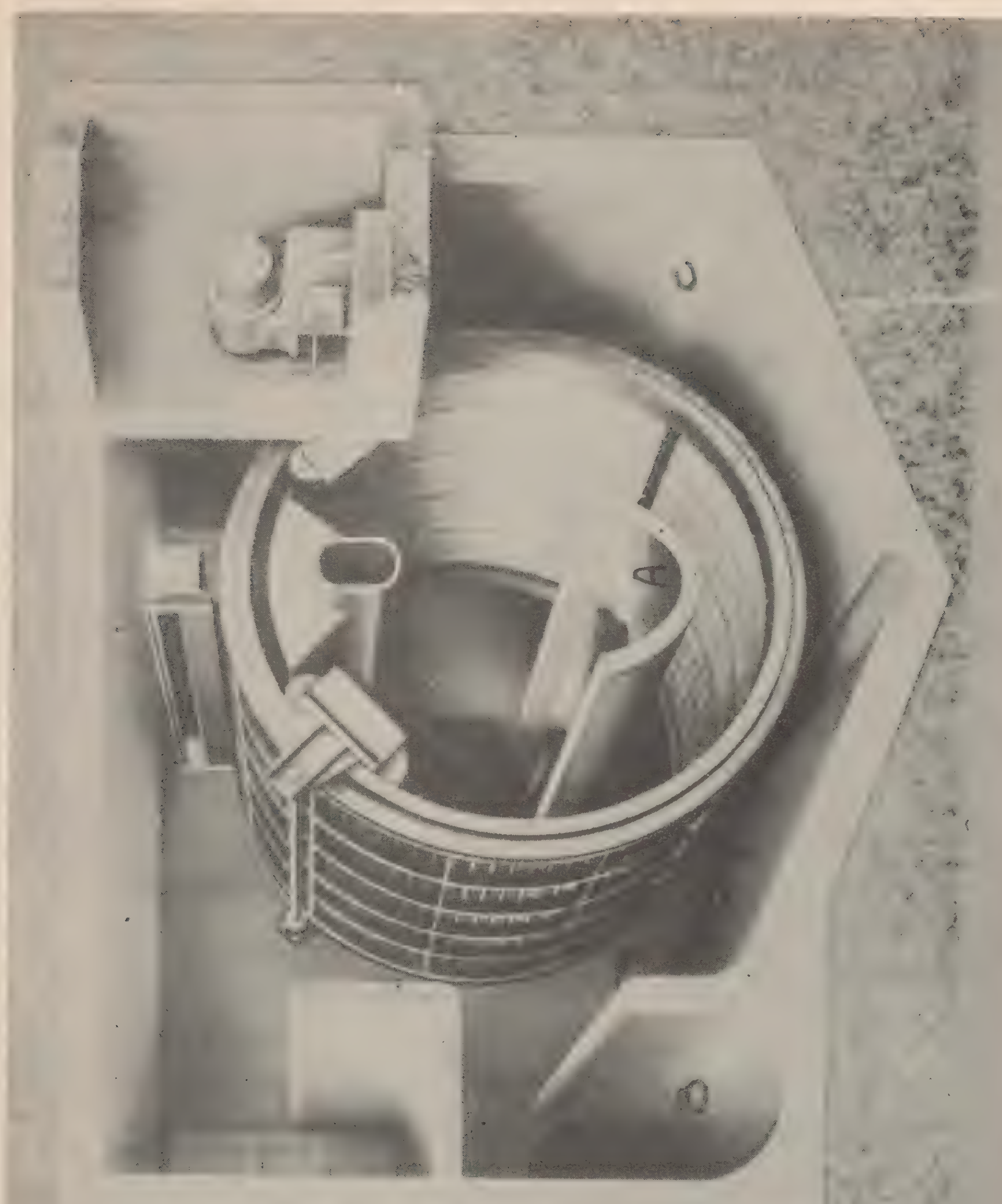


Fig. B-14-d, Geiger Storm Water Screen

Fig. B-14-e, Geiger Tangential Flow Grit-chamber

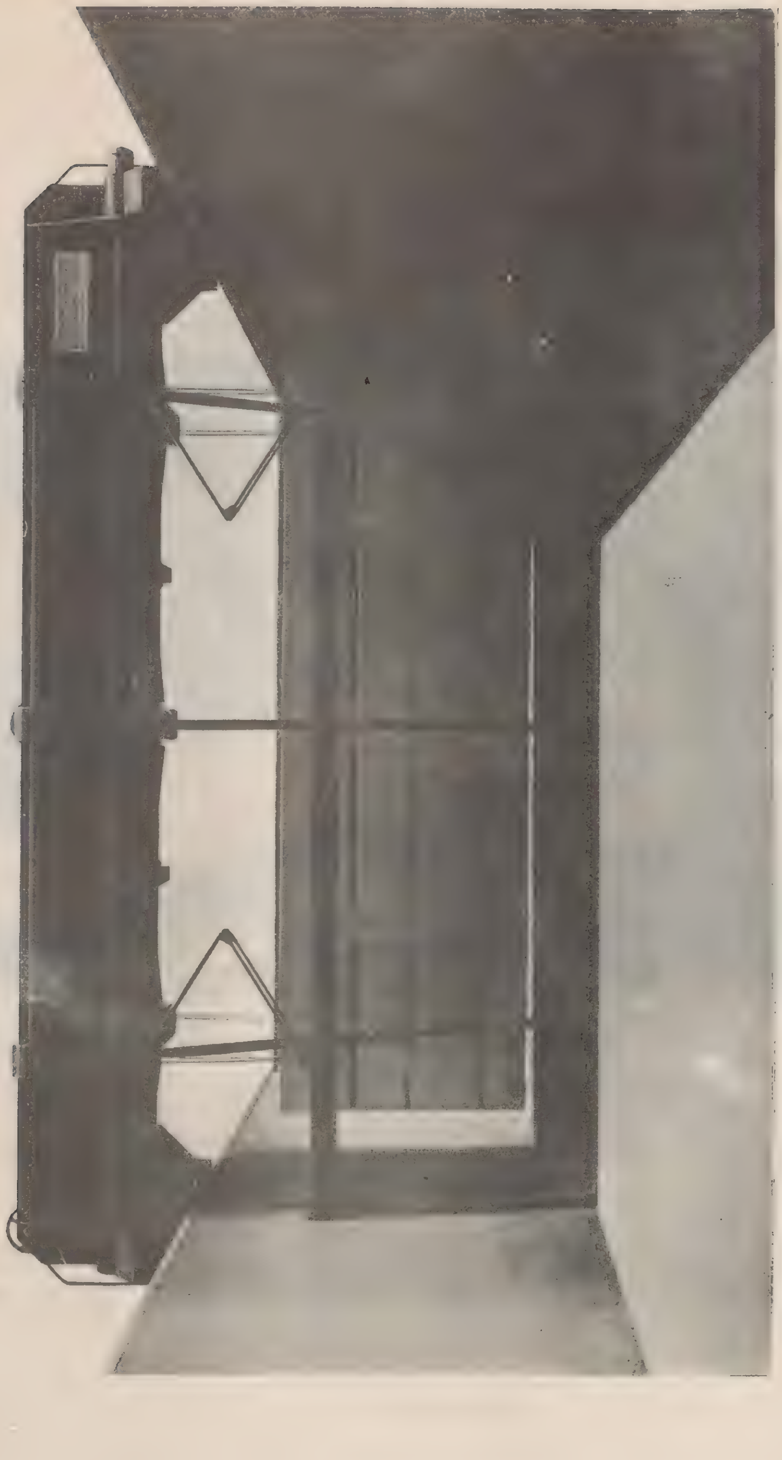


Fig. B-14-f, Geiger Rectangular Clarifier Mechanism

Abb. 3
Modell einer Klärgas-Tankanlage mit Kohlensäure-Auswaschung und mit Flaschen-Abfüllvor

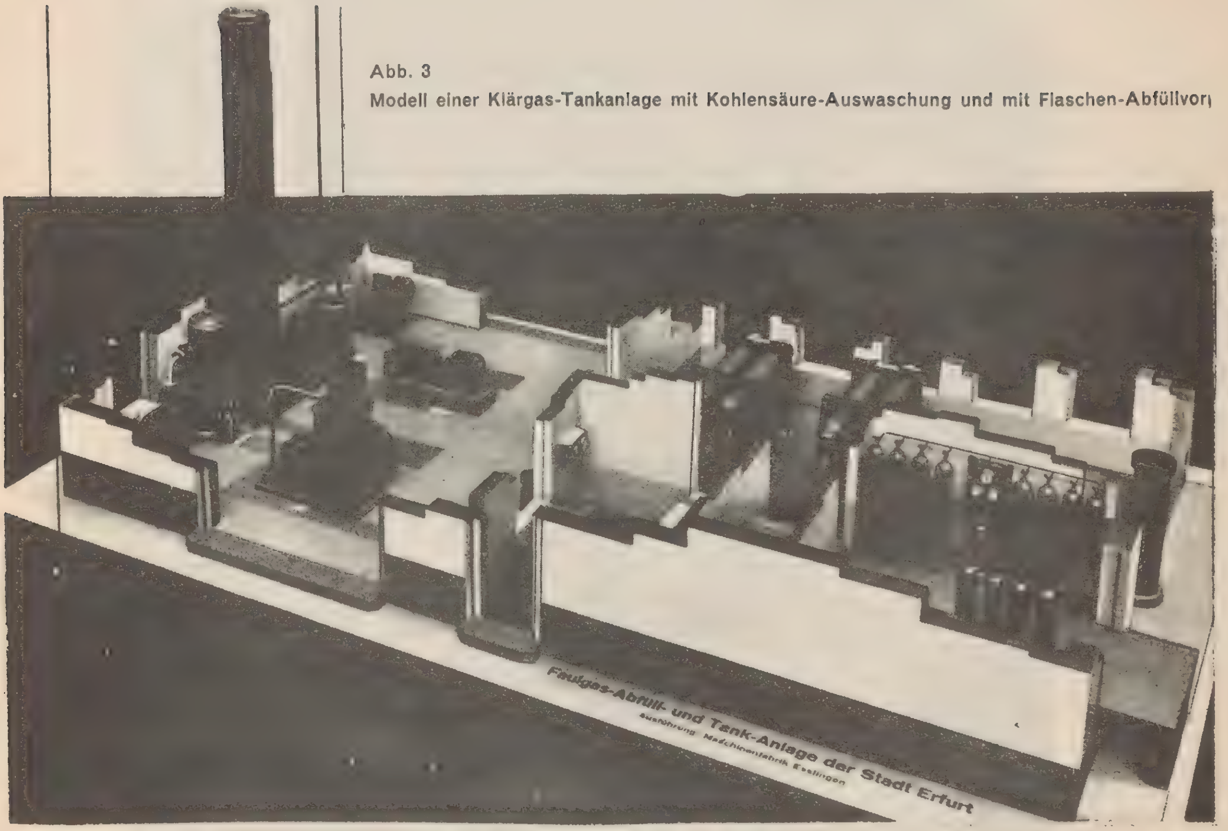
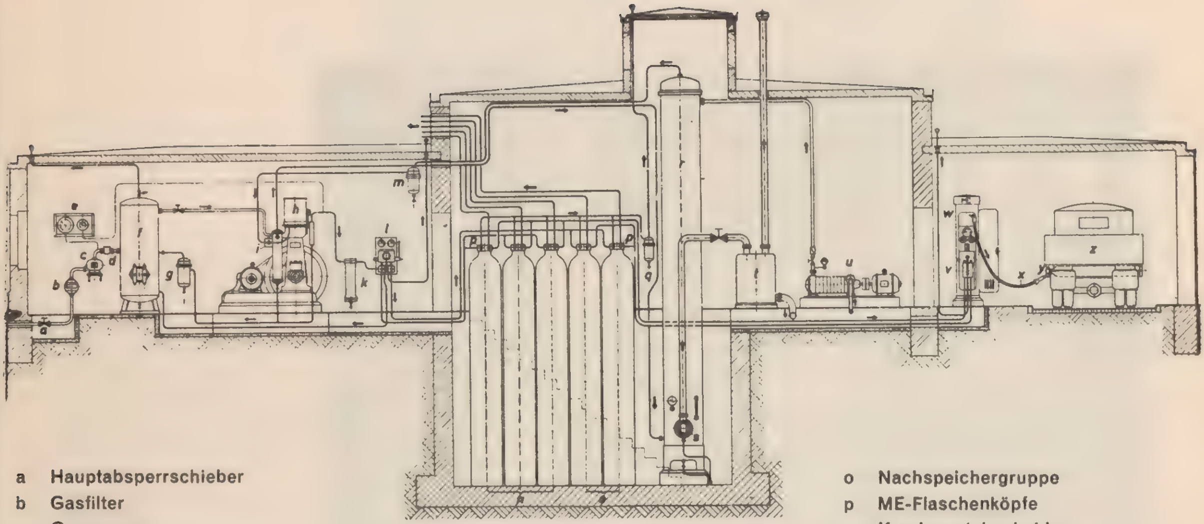


Fig. B-15-a, Model Sewage Gas Compression Plant



a Hauptabsperrschieber
b Gasfilter
c Gasmesser
d Rückströmdrosselventil
e Kontaktsicherheits-Druckmesser
f Saugwindkessel
g Kondensat-Sammelbehälter
h Vierstufiger Hochdruckverdichter
i Selbsttätiges Anfahrventil
k Chlorcalcium-Gastrockner
l ME-Steuerstand
m Wasserabscheider
n Vorspeichergruppe

o Nachspeichergruppe
p ME-Flaschenköpfe
q Kondensatabscheider
r Kohlensäure-Auswaschturm
s Selbsttätiger Wasserstandsregler
t Kohlensäure-Entspannungsgefäß
u Auswaschpumpe
v ME-Zapfblock
w ME-Zapfsäule
x Gastankschlauch
y ME-Hammerkopf-Anschluß
z Fahrzeug

Fig. B-15-b, Schematic Drawing Sewage Gas Compression Plant

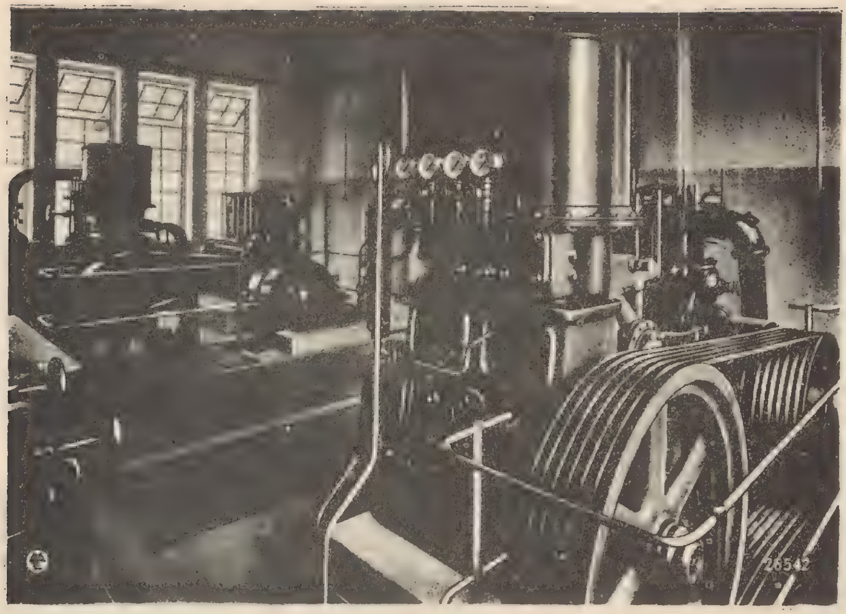


Fig. B-15-c, Gas Compressor-180 cu.meter/hour capacity

Fig. B-19-a, Hagen Sewage Plant

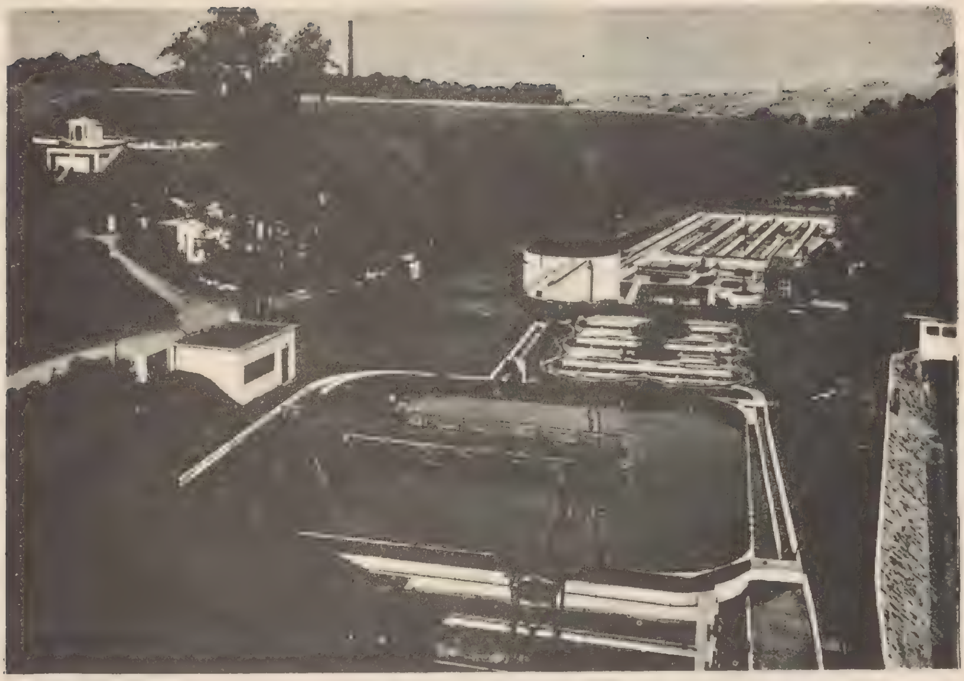


Fig. B-20-a, Essen-Rellinghausen Sewage Plant

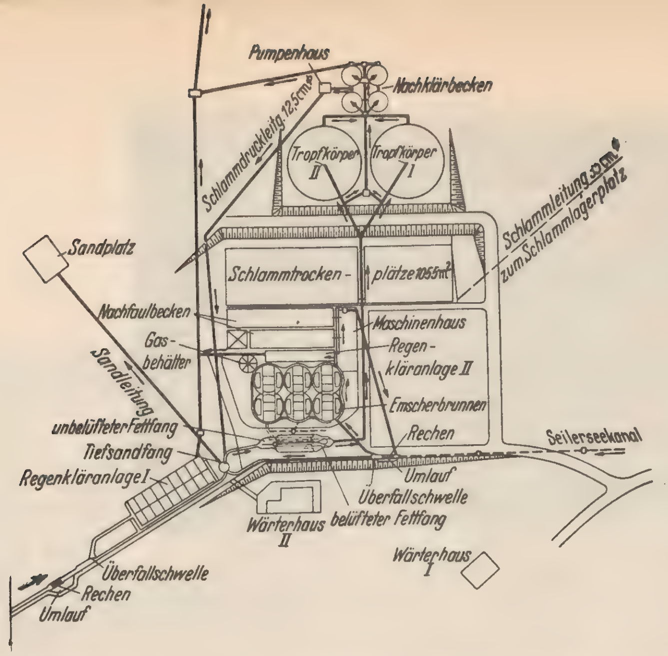


Fig. B-22-a, Iserlohn Sewage Treatment Plant. General Plan

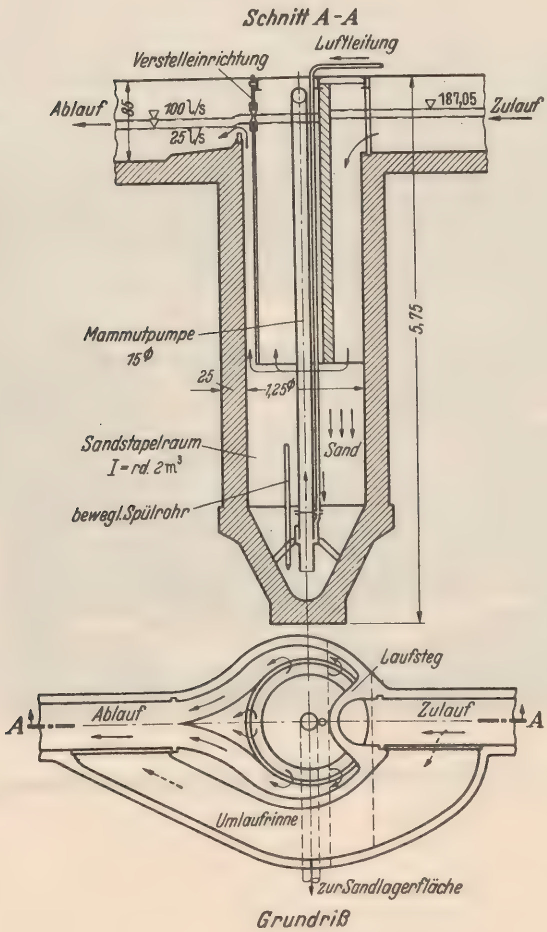


Fig. B-22-b, Iserlohn Grit Chamber

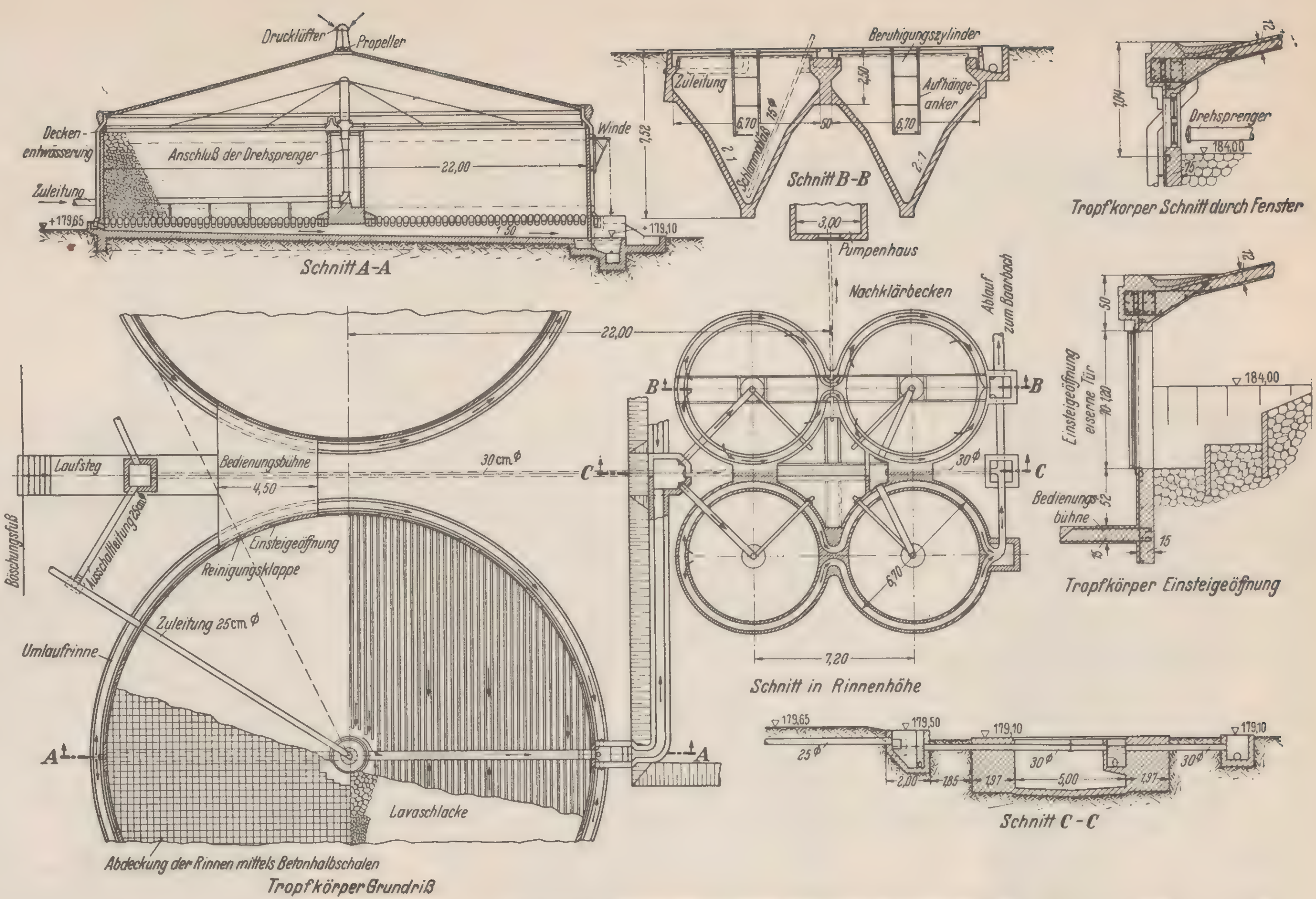


Fig. B-22-c, Iserlohn Enclosed Trickling Filter and Secondary Settling Tanks

Fig. B-23-a, Hattingen Sewage Treatment. Aerators in Operation

Fig. B-23-b, Hattingen Sewage Treatment. Aerator Empty

Fig. B-23-c, Hattingen Sewage Treatment. Digester Rotating Heating Coil

Fig. B-24-a, Essen-Nord Sewage Plant

Fig. B-24-b, Essen-Nord Digesters

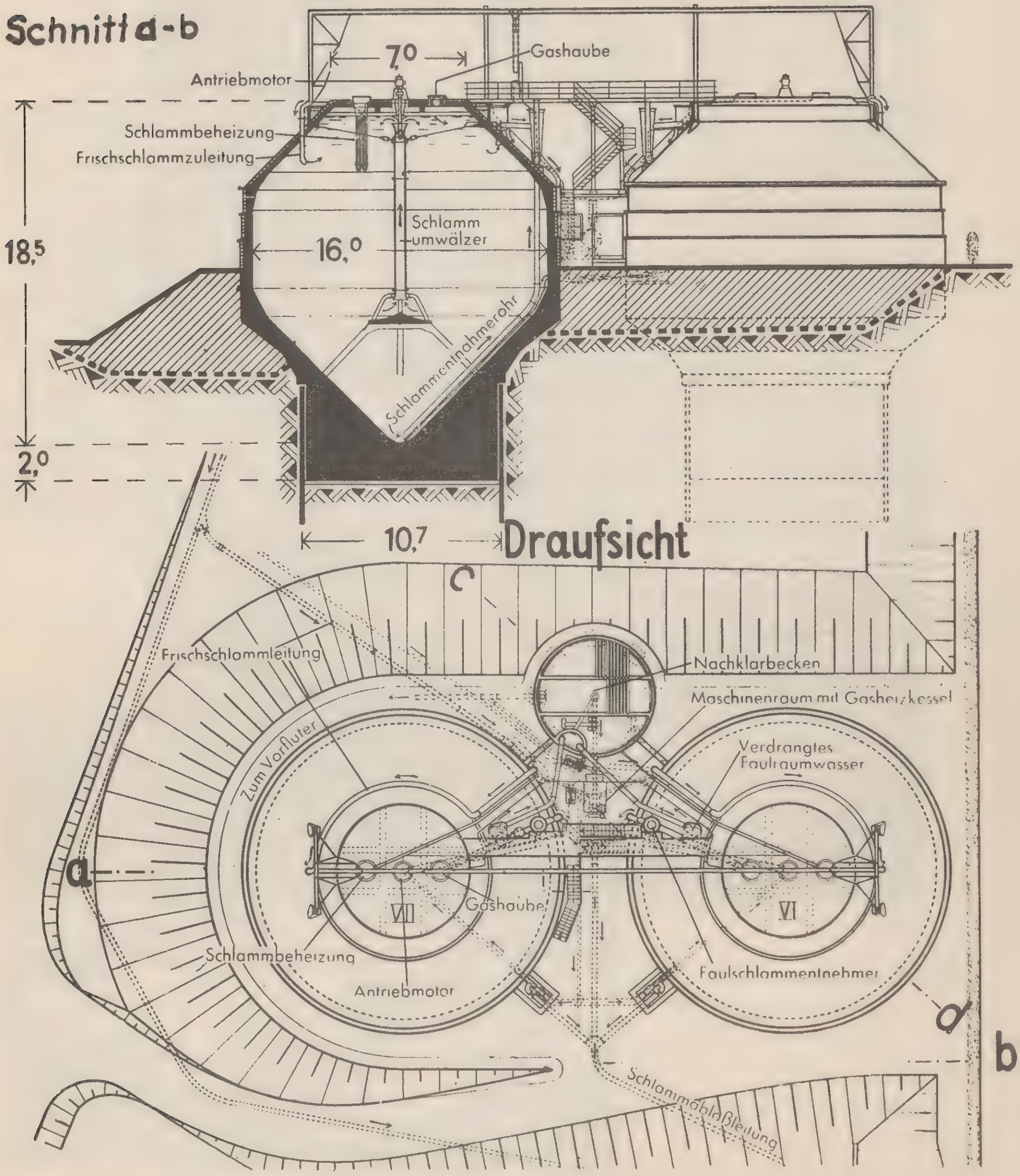


Fig. B-24-c, Essen-Nord Digester. Design Details

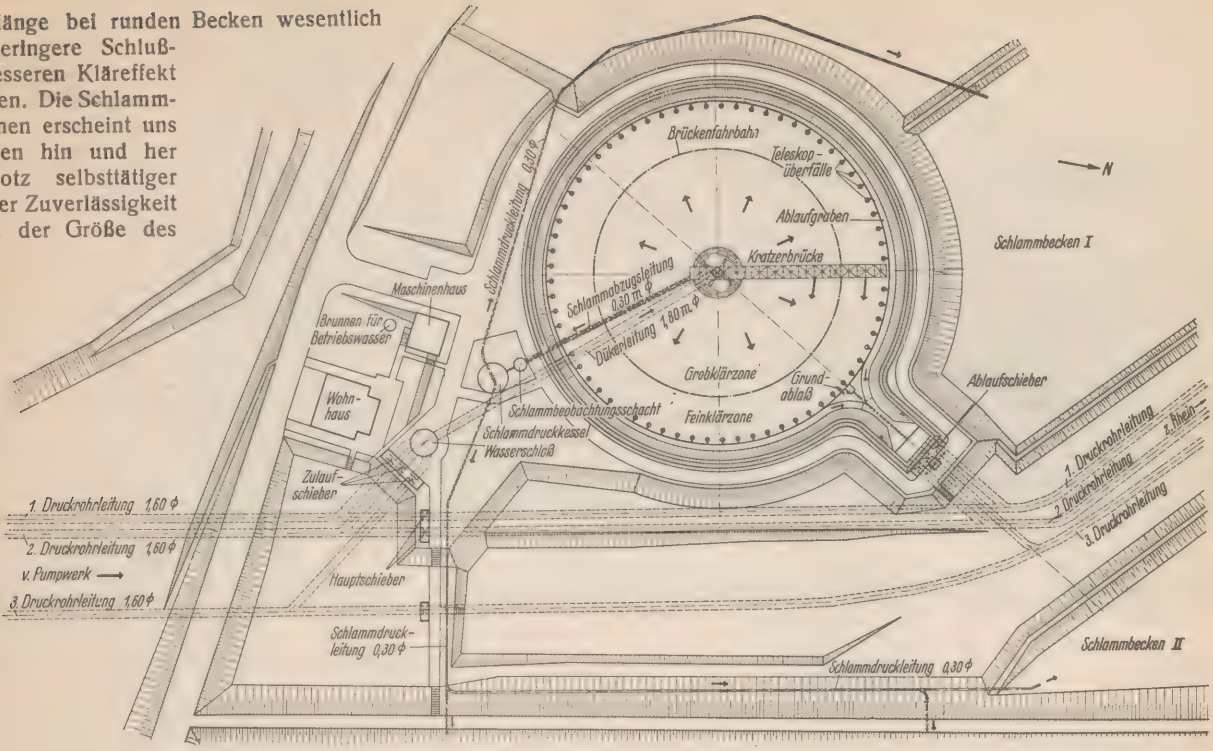


Fig. B-25-a, Alte-Emscher Sewage Plant. General Plan

Fig. B-25-b, Alte-Emscher Sewage Plant. Settling Tank in Operation

Fig. B-25-c, Alte-Emscher Sewage Plant. Sludge Removal Mechanism

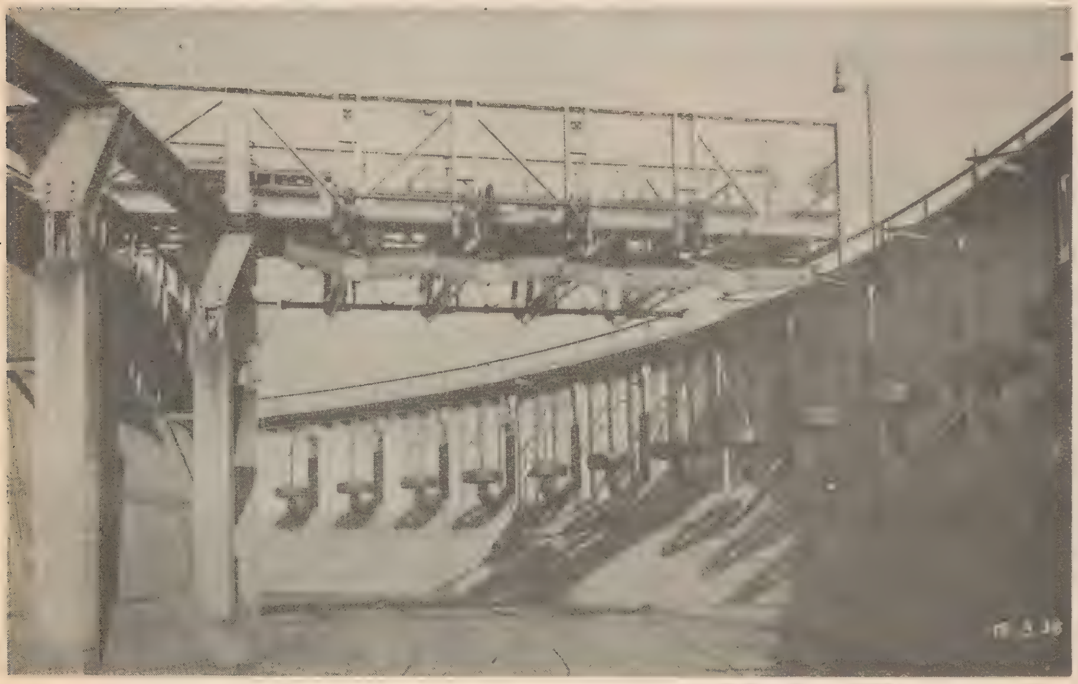


Fig. B-25-d, Alte-Emscher Sewage Plant. Floating Effluent Takeoff

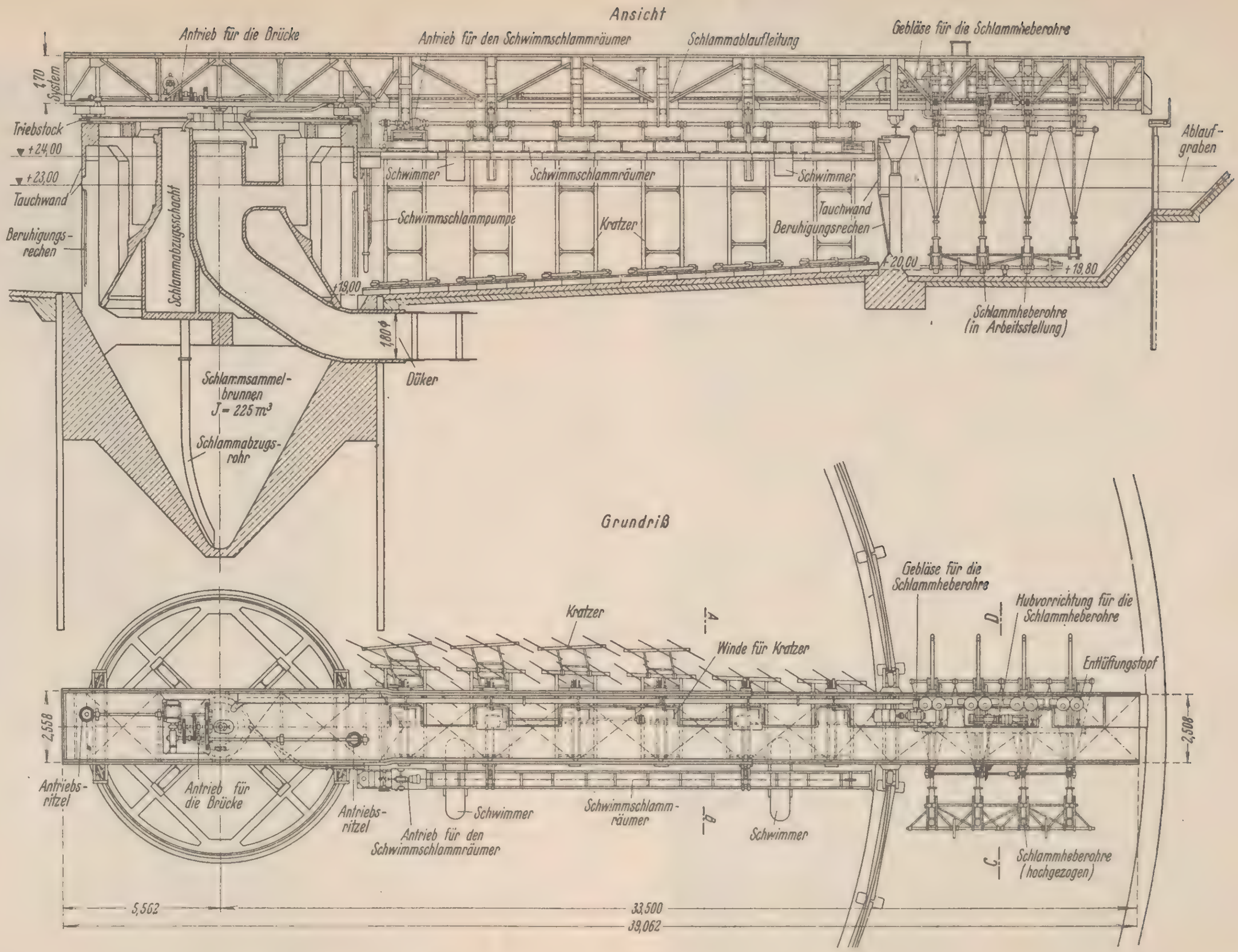


Fig. B-25-e, Alte-Emscher Sewage Plant. Details Sludge Removal Mechanism and Sludge Hopper

Fig. B-26-a, Karnap Sewage Plant

Fig. B-26-b, Karnap Sewage Plant. Close-up of Settling Tanks

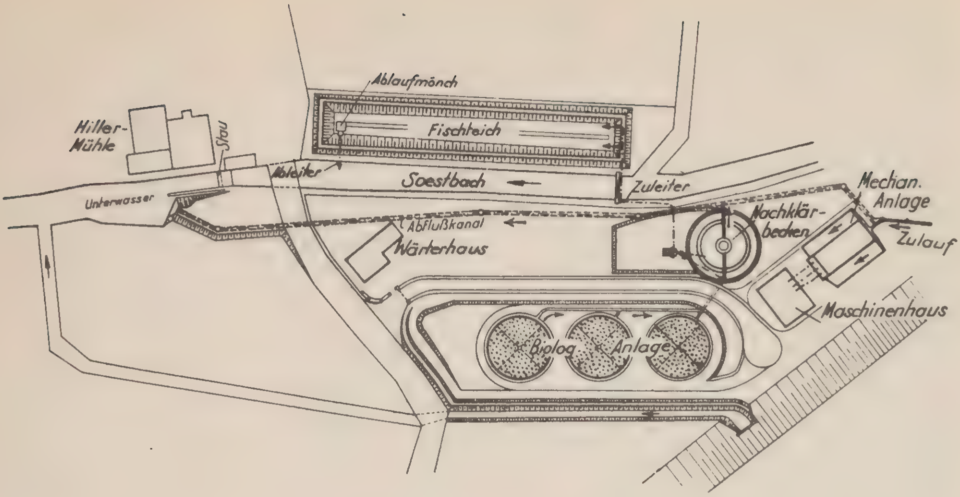


Fig. B-27-a, Soest Sewage Plant. General Plan

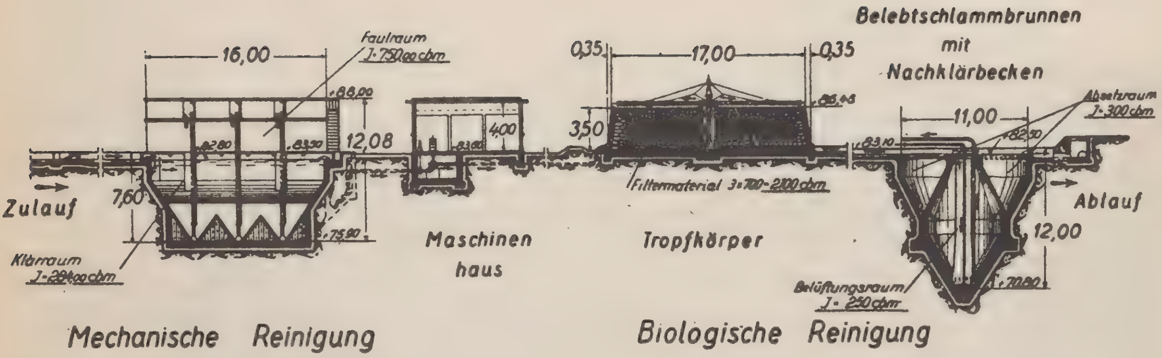


Fig. B-27-b, Soest Sewage Plant. Longitudinal Section thru Plant

Fig. B-27-c, Soest Sewage Plant. Air View

Fig. B-27-d, Soest Sewage Plant Combined Primary Settlers and Digesters

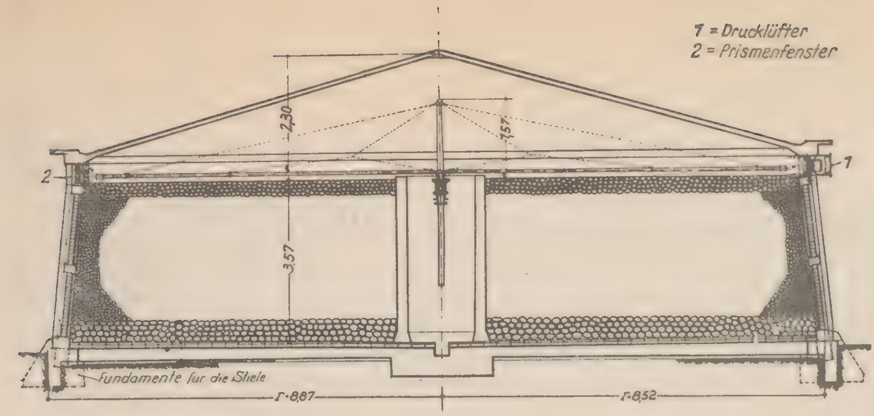


Fig. B-27-e, Soest Sewage Plant Design Trickling Filter

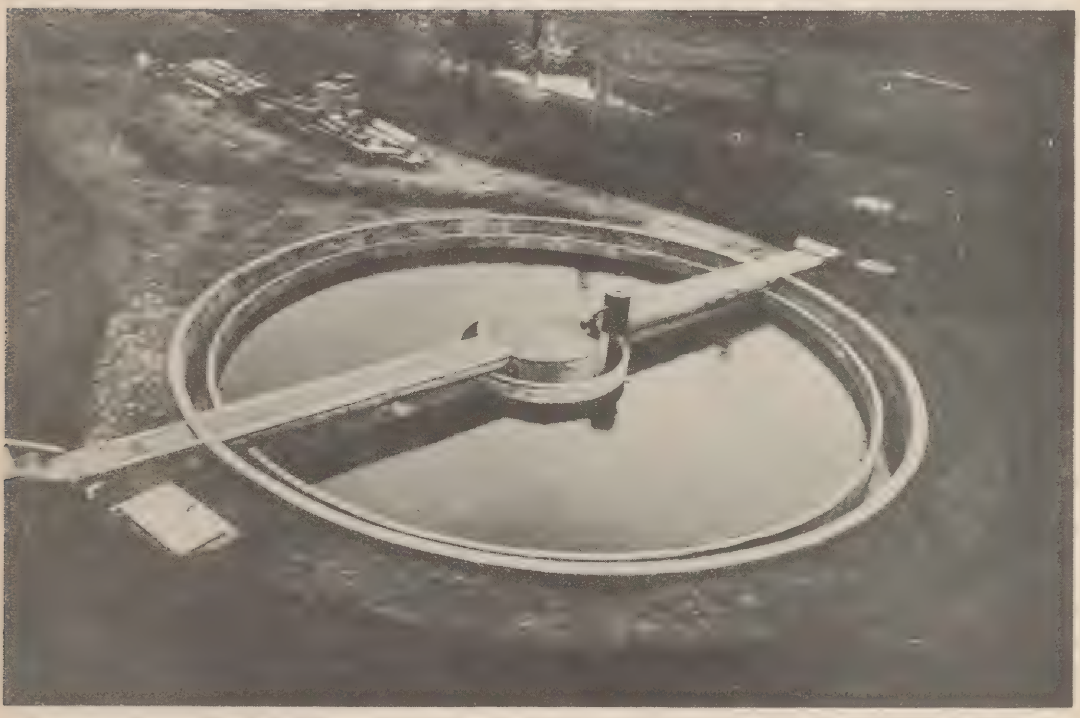


Fig. B-27-f, Soest Sewage Plant Combination Aeration and Settling Unit

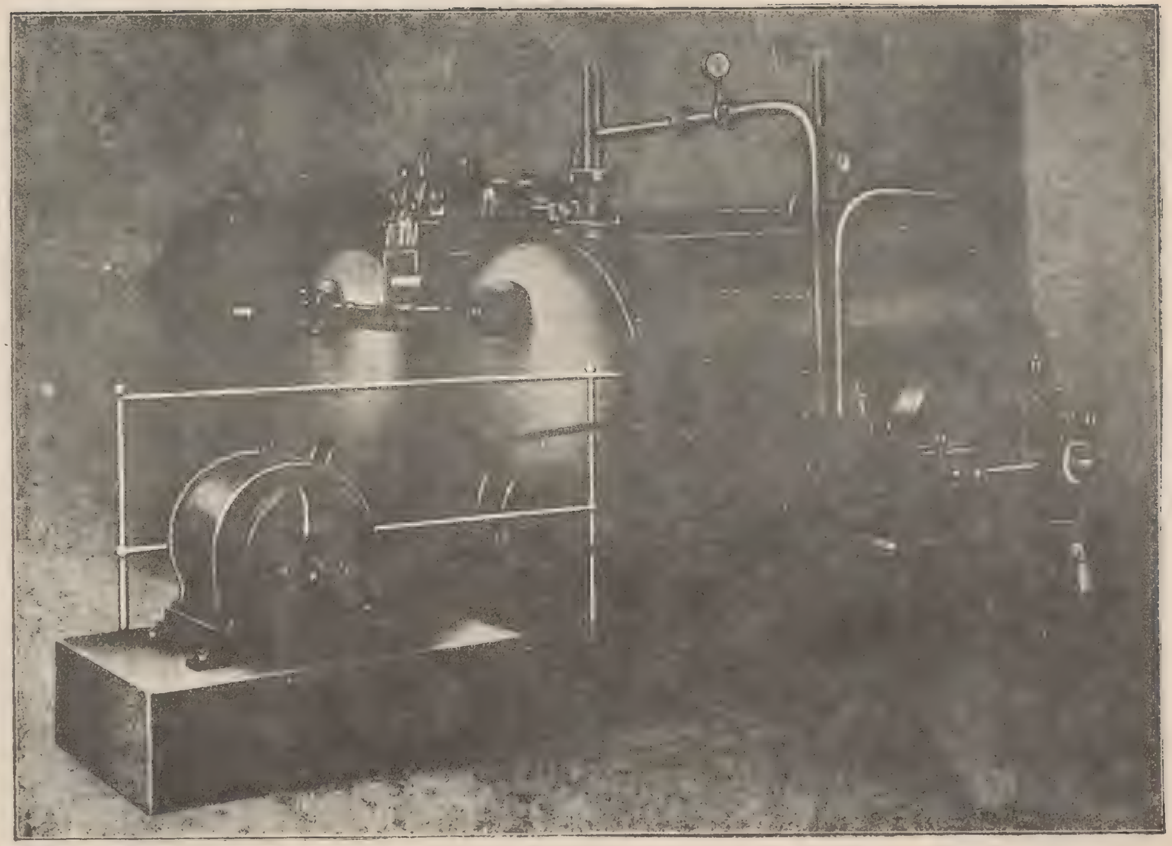


Fig. B-28-a, Frankfurt Vacuum System for Sludge Removal from Settling Tanks

Fig. B-29-a, Hildesheim Plant.
Bar Screen

Fig. B-29-b, Hildesheim Plant.
Treatment Unit for Digester Overflow

Fig. B-30-a, Berlin Stahnsdorf. Destroyed Gas Holder

Fig. B-31-a, Berlin Wassmannsdorf.
Gas Holding Tanks

Fig. B-31-b, Berlin Wassmannsdorf.
Damaged Aeration Tanks

Fig. B-31-c, Berlin Wassmannsdorf Damaged Aeration Tanks

Fig. B-31-d, Berlin Wasmannsdorf. Damaged Aeration Tanks

Fig. B-32-a, Nürnberg Digesters

Fig. B-32-b, Nürnberg Heat Exchanger

Fig. B-35-a, Stuttgart. Digester Heating Coils. View from floor.

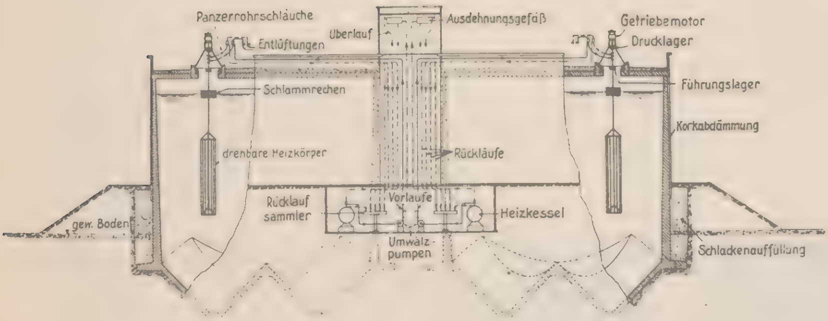


Fig. B-35-b, Stuttgart. Schematic Drawing of Digesters

Fig. B-35-c, Stuttgart. Trickling Filters

Fig. B-39-a, Bad Soden. Rotary Distributor

Fig. B-39-b, Bad Soden. Close-up of Rotary Distributor

REPORT

ON

WATER SUPPLY, SEWAGE, and INDUSTRIAL WASTE TREATMENT

IN GERMANY

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INDUSTRIAL WASTE TREATMENT

Industrial waste treatment targets visited by the group were as follows:

Target No.	
C-1	Reichsanstalt für Wasser und Luftgüte - Berlin, Dahlen
C-2	Ruhr District - Essen
C-3	Emscher District - Essen
C-4	Bamag-Meguin - Giessen
C-5	Lurgi Gesellschaft für Warmetechnik - Frankfurt am Main
C-6	Fabrik Hessisch Lichtennau - Eschentruth (near Kassel)

In addition to the above, information was obtained from the various equipment manufacturers and designing engineers listed in Section B regarding the number and type of installations built during the war years.

From the information gathered it appears that the following was the status of industrial waste treatment in Germany from 1938-45:

(1) About 70 plants were remodelled or built during this period. They were chiefly of the following types:

(a) Phenol waste treatment and recovery.
(b) Picling liquor (iron, copper, chromium).
(c) Acid neutralization (incl. TNT, dynamite plants, etc.)
(d) Oil removal.
(e) Coke wash water clarification.

(2) Recovery of valuable constituents in the waste liquors was stressed.

(3) In general, the plants built used the same type of units as are employed in the U.S., for mixing and settling.

(4) No new processes or major items of equipment for use in industrial waste treatment were developed in Germany during the war years. Considerable progress has, however, been made in perfecting techniques previously discovered and reported on. This work should be of definite interest to U.S. engineers.

(5) Items of special interest are:

(a) Methods of treating cyanide wastes (Target C-1)
(b) Methods of treating chromate wastes (Target C-1)
(c) Methods of treating pickling liquor wastes (Target C-2)
(d) Methods of treating copper wastes (Target C-2)
(e) Methods of treating phenolic wastes (Targets C-1, C-3 and C-4)
(f) Equipment for handling coke wash water (Target C-5)
(g) Stage neutralization of acid waste by means of automatic pH valve control (Target C-6)

DETAILED TARGET REPORTS

TARGET NO. C-1

Name: Reichsanstalt für Wasser und Luftgüte

Location: Berlin-Dahlem

Date Visited: July 28, 1945

Person Interviewed: Prof. Dr. F. Meinck

Interviewed By: Fischer, Gorman

INFORMATION OBTAINED

Prof. Meinck stated that during the war the sewage department of the Reichsanstalt concerned itself chiefly with the treatment of industrial wastes. In this connection, he had made special studies on the treatment of cyanide and chromate wastes and of phenolic liquors. A technical paper by Meinck dealing with cyanide wastes appeared in "Die Metallwaren-Industrie und Galvanatechnik", September 1, 1942. A review of methods of treating chromate was presented in the same journal February 10, 1944.

Two flow sheets recommended for handling large amounts of cyanide wastes are shown in Figures C-1-a and C-1-b. In the first case, the waste is treated with lime and chlorine, mixed with air and then settled. In the second, it is acidified and aerated in a covered aeration tank, then alkalinized with lime to a pH value of 8.5-9.0, mixed and settled. Older methods of treatment involving adding iron sulfate with the production of complex potassium ferri-ferrocyanide are said to be unreliable and are not recommended.

For the treatment of chromate waste the method devised by Spenser ("Sewage Purification", 1939, p.356-7) is recommended. This scheme is illustrated in Figure C-1-c. Here one reaction tank is being filled while the other is in operation, its contents being treated with sodium carbonate and barium chloride solutions. Sufficient soda must be added to maintain alkaline conditions. Barium chloride must be added in excess of the amount required to react with the sulfates present in the waste. The excess may be carried as high as

720 ppm. After adding the soda and barium salt the mixture must be aerated five minutes and then settled for about one hour. In order to precipitate any excess barium salts, an excess of soda is then added and the mixture again aerated five minutes after which it is allowed to settle overnight. The next day the sludge is withdrawn to drying beds while the clear supernatant liquor is slowly discharged to the receiving stream.

In treating phenolic liquors, Prof. Meinck mentioned the "P" method as being of interest. In this method waste containing as high as 10,000 ppm phenol may be treated by the activated sludge process. It involves first carbonating the waste to reduce the pH value to 7.0-8.5 and then adding 75 ppm of nutrient salts containing nitrogen and phosphorus so as to maintain a C:N:P ratio at approximately 15:1:o.1 or less. Salts added may be $(NH_4)_2\ SO_4$ and $(NH_4)_3\ PO_4$. The waste diluted 1:1 with river water is then aerated for 24 hours in the presence of 20% return sludge. Relatively high air quantities are required. After settling, a coffee colored effluent containing 75 ppm phenols is said to be produced. According to Prof. Meinck aeration was reported to be better than trickling filters. He believed the reverse should be true. The "P" process was said to be patented in Germany by its inventor Nolte of Flusswasseruntersuchings, Magdeburg.

ITEMS OF INTEREST

Methods described for treating cyanide, chromate and phenol waste are of interest in the U.S.

NEW PROCESSES OR EQUIPMENT

All of the above methods although not new, are not generally known in the U.S.

TARGET NO. C-2

Name: Ruhr District

Location: Essen

Dates Visited: June 28, 29, 1945

Person Interviewed: Dr. Sierp

Interviewed By: Fischer, Lt.Col.Gilbert, Gorman, Sheridan

INFORMATION OBTAINED

Copper bearing waste waters may be treated with fine iron filings whereby the copper is precipitated and settled. By subsequent contact filtration thru a bed of iron turnings, a 100% removal of copper from the waste water may be effected. The flow sheet is shown in Figure C-2-a. Results have shown that a reduction from 250 ppm Cu down to 0 ppm may be effected by use of this process. The copper may be recovered from the sludge. Briquettes showed 93% copper content after roasting. A small recovery plant using this principle has been constructed at the Busch-Yaeger works near Iserlohn to treat 45 cu. meters/day of waste water. The plant as constructed employed the flow sheet of Figure C-2-b wherein two-stage combination iron precipitation settling tanks were used. A typical combination unit is shown in Figure C-2-c.

Typical results of a continuous flow laboratory test showed the following:

	Waste Water	
	Before Treatment	After Treatment
Copper (Cu), ppm	335	0
Zinc (Zn), ppm	218	218
Free HNO_3, ppm	1030	753
Free HNO_2, ppm	60	0
Iron (Fe), ppm	0	1100
NH_3, ppm	-	95
Acidity - cc. $\frac{N}{10}$ NaOH	845	540

Studies on the treatment of pickling liquor wastes have shown that by use of the flow sheets shown in Figures C-2-d and C-2-e, losses of sulfuric acid may be greatly

reduced. In the Ruhr District, pickling liquor contains 600-800 ppm $FeSO_4$. Twenty thousand tons of H_2SO_4 per year were normally required before the war. Forty percent of this acid was lost. This loss was reduced to 10-15% by removal of $FeSO_4$ by crystallization.

In the process the pickling liquor is discharged at 60°C. Fresh sulfuric acid is added to increase the concentration of acid from 2-5% up to 25%. The material is then cooled from 60°C down to 15°C in lead pipe heat exchangers. $FeSO_4.7H_2O$ crystallizes out and may be removed by centrifuges or by filtration. Centrifuges were said to be best for large plants. An installation using this process has been installed at Largersberg near Neviges.

The average amount of crystallization of $FeSO_4.7H_2O$ at various temperatures in the presence of 50-150 ppm H_2SO_4 is given as follows:

Specific gravity at 55°C	Temperature where cryst. of salts begins °C.	Crystal. of salt; kg$FeSO_4.7H_2O/m^3$ solution at the beginning 5°C	10°C	15°C	20°C	25°C	30°C
1,10	below 0	0	0	0	0	0	0
1,12	below 0	0	0	0	0	0	0
1,14	below 0	0	0	0	0	0	0
1,16	0 - 5	2	0	0	0	0	0
1,18	3 - 9	12	0	0	0	0	0
1,20	- - 14	62	14	0	0	0	0
1,22	14 - 17	117	70	14	0	0	0
1,24	18 - 22	172	127	70	7	0	0
1,26	22 - 27	228	185	130	62	4	0
1,28	27 - 31	284	244	194	129	53	0
1,30	31 - 35	343	302	255	194	119	35
1,32	35 - 40	398	360	314	255	182	107
1,34	38 - 42	455	420	375	318	252	178
1,36	42 - 46	513	480	437	386	318	252
1,38	47 - 50	573	540	501	450	387	327
1,40	52 - 54	630	602	565	516	458	402

Other research work is under way on the treatment of copper, nickel, zinc and chromium waste. No definite results are as yet available on this work. Indications, however, are that nickel may be effectively removed by activated carbon.

Some base exchange work has been carried out using "Wolfanite". This material was found satisfactory for treating liquids of low salt concentration, but not for waste containing high amounts of metals in solution, such as pickling liquors, etc.

GENERAL OBSERVATIONS

Due to the shortage of copper in Germany, the recovery of the metal from the waste water is probably stressed more than the reduction of the germicidal nature of the waste. In the U.S., it is questionable whether the recovery step would be economically justified.

ITEMS OF INTEREST

Both the methods of treating pickling liquor and copper bearing waste waters should be of interest in the U.S.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. C-3

Name: Emscher and Lippe District

Location: Essen

Date Visited: June 29, 1945

Person Interviewed: Mr. Wiegmann

Interviewed By: Fischer, Lt.Col.Gilbert, Gorman, Sheridan

INFORMATION OBTAINED

In treating phenolic liquors in the Emscher District a reduction to 100 ppm is ordinarily considered satisfactory. In the Ruhr District, however, where the waste waters eventually flow to underground sources of water supply, much greater removals are necessary, and biological methods of treatment are required.

In a typical benzol extraction plant visited near Essen (see Figure C-3-a), 3,000-4,000 tons of coal are normally converted to coke, etc. In this operation, 300-500 cu.meters/day of phenolic liquors are produced. By washing with benzol - 70-80% by volume - a 1.5 grams/liter phenol extract is produced. The washing period required is one hr. Upon settling, following mixing, a separation of benzol and phenol takes place. The benzol is then washed with NaOH in sufficient quantity to produce sodium phenolate. This is shipped in tank cars to a nearby plant for the production of plastics. A typical flowsheet showing this operation is shown in Figure C-3-b.

In 1939, there were 65 coke oven plants in the Emscher and Ruhr Districts. In about half these installations phenol recovery was practiced. The annual raw phenol and cresol production from these plants amounted to 5670 tons per year in 1939. These phenol recovery plants are owned and operated by the Emscher District. (See Fig. 8-B-a).

GENERAL OBSERVATIONS

According to Mr. Wiegmann, there had been no basic improvements made in the phenol system used by the Emscher District during the war years. All plants were shut down

due to extensive bomb damage to practically all coke oven installations, and to general cessation of industrial activity at the end of the war.

ITEMS OF INTEREST

None.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. C-4

<u>Name</u>: Bamag-Meguin A.G.

<u>Location</u>: Giessen

<u>Date Visited</u>: July 13, 20, 1945

<u>Person Interviewed</u>: No

<u>Interviewed By</u>: Fischer, Lt.Col.Gilbert, Sheridan

INFORMATION OBTAINED

Equipment was offered by this company in 1944 for use in clarifying wash water used in coke oven plants which consisted of a mechanism operating in a circular tank. In this design segmental feed and overflow was employed, the overflow passing up thru a filter bed of coke before being discharged from the tank. Sludge settled in a series of concentric trenches on the floor of the tank and was scraped by plows to two sumps. From here it was picked up by pumps and delivered to a storage tank where excess water was decanted. The plows were suspended from an overhead bridge or truss which was slowly rotated on a circular peripheral track by a suitable drive unit.

Earlier types of this unit, first constructed in 1927 and described in detail in "Stahl and Eisen" 1929, vol.3, and in "Glückauf" 1929, Nr.42, are shown in Figures C-4-a and C-4-b. Both of these have center feed and peripheral overflow thru coke beds. In one the plows are rotated on a center shaft while in the other a traveling bridge is used, a single plow being employed. This plow could be raised and lowered and also moved radially so that it could be used in all the trenches.

In one of the 1929 designs, one tank 25 meters diameter x 5.6 meters effective water depth was used to clarify 900 cu.meters of wash water per hour. The coke filter was cleaned by backwashing.

GENERAL OBSERVATIONS

The concrete work required by this type of construction is considerably more complex than in conventional U.S. designs. For this reason it is questionable whether its use would be economically justified in the U.S.

ITEMS OF INTEREST

The use of an upflow coke filter suspended in the settling tank is of interest in view of subsequent work with the "Magnetite Filter" in which a similar construction was used.

NEW PROCESSES OR EQUIPMENT

None.

TARGET NO. C-5

Name:	Lurgi Gesellschaft für Wärmetechnik m.b.H.
Location:	Frankfurt am Main
Date Visited:	July 11, 15, 1945
Persons Interviewed:	Drs. Bailleul, Khort
Interviewed By:	Fischer, Lt.Col.Gilbert

INFORMATION OBTAINED

The Lurgi Company and I.G. Farbenindustrie jointly developed a method of treating phenolic liquors for the recovery of phenols by a method known as the "Phenolsolvan Process".

Phenolsolvan is a mixture of esters of aliphatic alcohols. It has a density of about 0.88 and vaporizes between 110°-130°C. Its phenol dissolving power is unusually high. Whereas with benzol, 100-200% by volume of solvent is required, with phenolsolvan only 10% is needed in order to reduce the phenol content of the water to 0.1-0.2 grams/liter.

The extraction is carried out counter-current in a number of stages. The washing stages are comprised entirely of a system of pumps and separators. Emulsification between the extraction material and the phenol containing water does not occur because Phenolsolvan possesses the emulsion destroying properties of ether. Phenols are recovered or removed from the extract by distillation, clear water white Phenolsolvan being returned to process. As the boiling point of Phenolsolvan is lower than that of phenol and tar oils, it can be used in a system for a very long time before it needs to be purified for the removal of tar. Because of this the quantity of phenol dissolved in a given plant is always held constant.

Typical Phenolsolvan flowsheets are shown in Figures C-5-a and C-5-b. A technical article describing this process and comparing it with other extraction processes was presented by Dr. W. Hubert of the Lurgi Company in "Oel und Kohle", vol.19, pp.525-31, 1942.

ITEMS OF INTEREST

This process, commercially developed in Germany during the war may be of interest in the U.S.

NEW PROCESSES OR EQUIPMENT

Although this process is not entirely new, details of construction, etc., are novel.

TARGET NO. C-6

Name:	Fabrik Hessisch Lichtennau Zur Verwertung Chemischer Erzeugnisse
Location:	Eschentruth (near Kassel)
Date Visited:	July 9, 1945
Person Interviewed:	Dr. Eckardt
Interviewed By:	Fischer, Lt.Col.Gilbert, Gorman, Sheridan

INFORMATION OBTAINED

This was a TNT and shell loading plant located at Camp Mahogany about 15 miles northwest of Kassel. It discharged five different types of waste waters as follows:

(1) Tar and phenol waste liquor.
(2) Strong acid waste water containing very little TNT.
(3) Acid waste water containing some TNT (red color).
(4) Alkaline waste water containing high amount of TNT (red color).
(5) Cooling water.

The coal tar was removed from the phenolic liquor by passing the liquor thru four longitudinal tanks in series, any one of which could be withdrawn from service for cleaning without affecting continuous operation. Each tank provided a 24-hour detention period and contained three vertical filters near the effluent end thru which the liquor flowed. Each filter was 8" thick and was filled with excelsior. An overhead traveling crane removed the filters which were burned and refilled when the loss of head became excessive.

Some of the tar floated in the tanks and was hand skimmed. Some settled to the tank bottom and was periodically removed when a tank was taken out of service. The remainder was caught on the filters. The tank effluent, high in phenols, was used for quenching ashes and coke. The daily flow of this liquor was 60 cu.meters.

The red alkaline water, amounting to 3000 cu.meters per day (from a TNT production of 3500 tons per month) was settled one hour in two plain settling tanks, each with a

holding capacity of 120 cu.meters. Each unit was divided into four compartments by vertical baffles. One tank was in operation while the other was being cleaned. After emptying out a tank, the settled powder was shovelled out by hand and returned to process.

The settled effluent was then combined with acid waste No.3, building drainage and picric acid waste water. The pH value of this combined waste was 1.0 or less. Lime was then added to the combined waste in a premix channel in three stages. The lime added at each stage was automatically regulated by pH recorders activating automatic cone valves. In the first stage of lime addition, the pH value was raised to 4.0-5.0; in the second stage to 5.0-7.0. In the third stage, the settled effluent was maintained at pH 7.0

The lime dosed waste flowed to two rapid mix tanks equipped with Bamag impeller mixers. Each of these units had a capacity of 60 cu.meters. One unit was operated at a time. At a total flow of 5000 cu.meters/day, the average detention period in one of these units was about 17 minutes.

After mixing, the lime dosed waste flowed to two Bamag Mieder type settling tanks each having a capacity of 400 cu.meters. Here again one unit was operated while the other was held in reserve. The settled effluent was run to large concrete holding tanks, and thence to the Fulda River.

The No.2 acid waste was treated separately but in the same manner by means of lime, in another plant alongside the other. This effluent was not as corrosive as wastes 3 and 4, and was partly used for cooling water in the H_2SO_4 manufacturing plant.

Two hundred tons of lime were used per day in this neutralization plant. The dry lime ($Ca(OH)_2$) was air conveyed from storage to pressure type mixers where it was mixed with water. These units resembled "Pfaudler" stills and had a capacity of 15 cu.meters each. These mixers were operated continuously to provide normal lime requirements. Three additional 60 cu.meter lime storage tanks with mixers were provided for peak requirements. Due to storage, 20% of the lime in these tanks converted to carborates. The pumping of lime slurry was said to be difficult, and the only satisfactory pump found for this service was said to be the "Dukstuff" pump made by a Vienna manufacturer.

Sludge from the four settling tanks (from the two plants) was dewatered by means of vacuum filters and dumped

nearby. Due to the shortage of sulfur in Germany during the war, consideration was being given to the treatment of this sludge for the recovery of Sulfur. The process was being developed by the Lurgi Company of Frankfurt, and involved reducing the $CaSO_4$ of the sludge to CaS by heating with coal and treating the sulfide with acid to give free sulfur. Due to the ending ~~XXXXXXXXXXXXXX~~ of the war this process was never perfected.

The pH recorders used in this plant were supplied by Siemens and BAMAG; the automatic cone valves by Schuhmann of Leipzig and Lautenschlager of Munich.

GENERAL OBSERVATIONS

The plant was not in operation at the time it was visited. It had suffered no bomb damage due to its being concealed in a heavy woods. The plant appeared to be too complicated and cumbersome. Dr. Eckardt who designed and had charge of the installation admitted that evaporation and burning of the "red liquors" was a more logical solution for these wastes.

ITEMS OF INTEREST

The pH control and automatically regulated valve in use at this plant should be of interest to U.S. engineers.

NEW PROCESSES OR EQUIPMENT

None.

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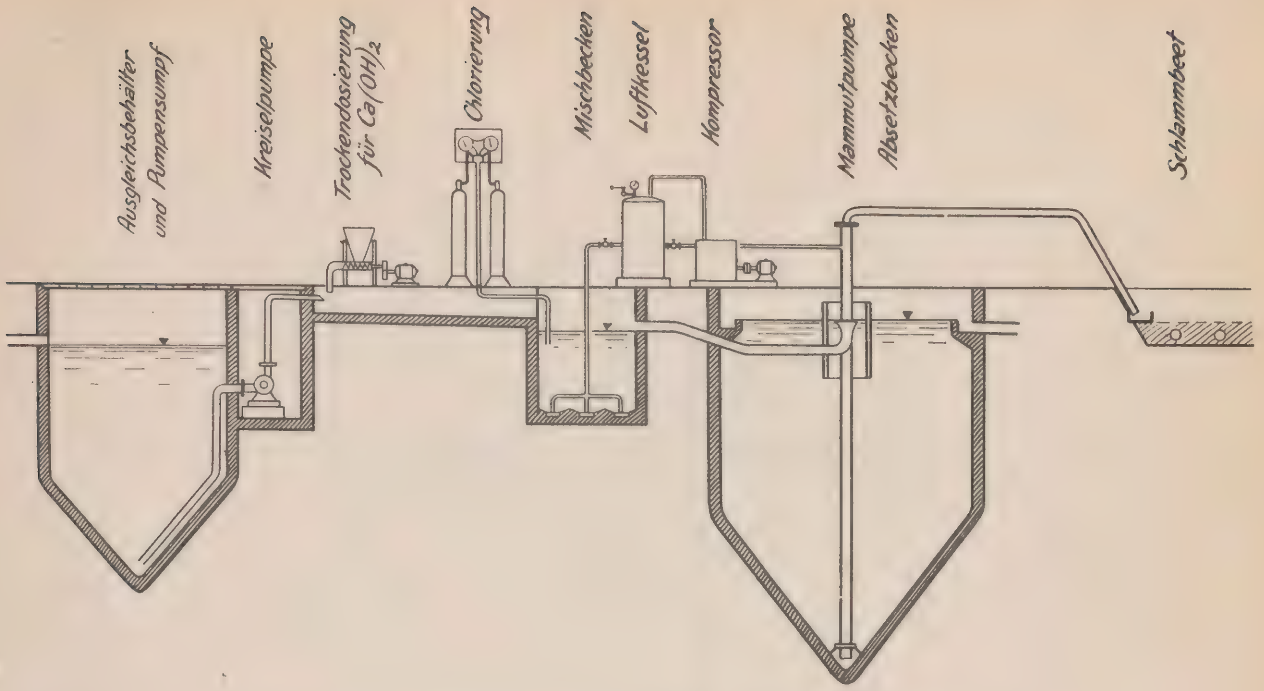

Fig. C-1-a, Cyanide Waste Treatment, Using Lime and Chlorine

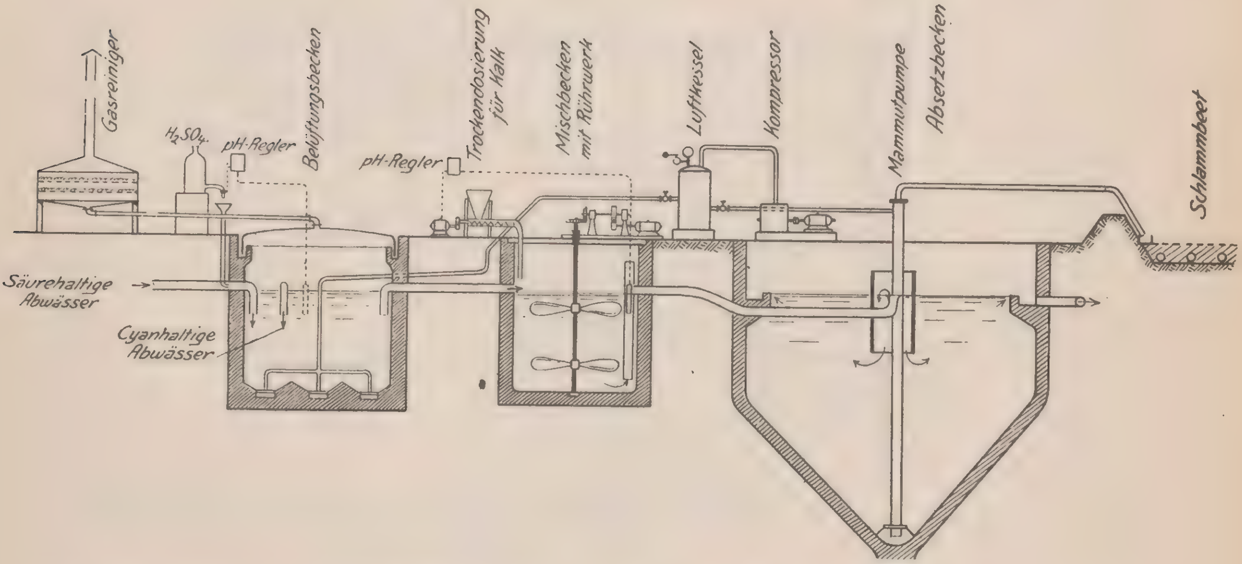

Fig. C-1-b, Cyanide Waste Treatment, Using Acidification

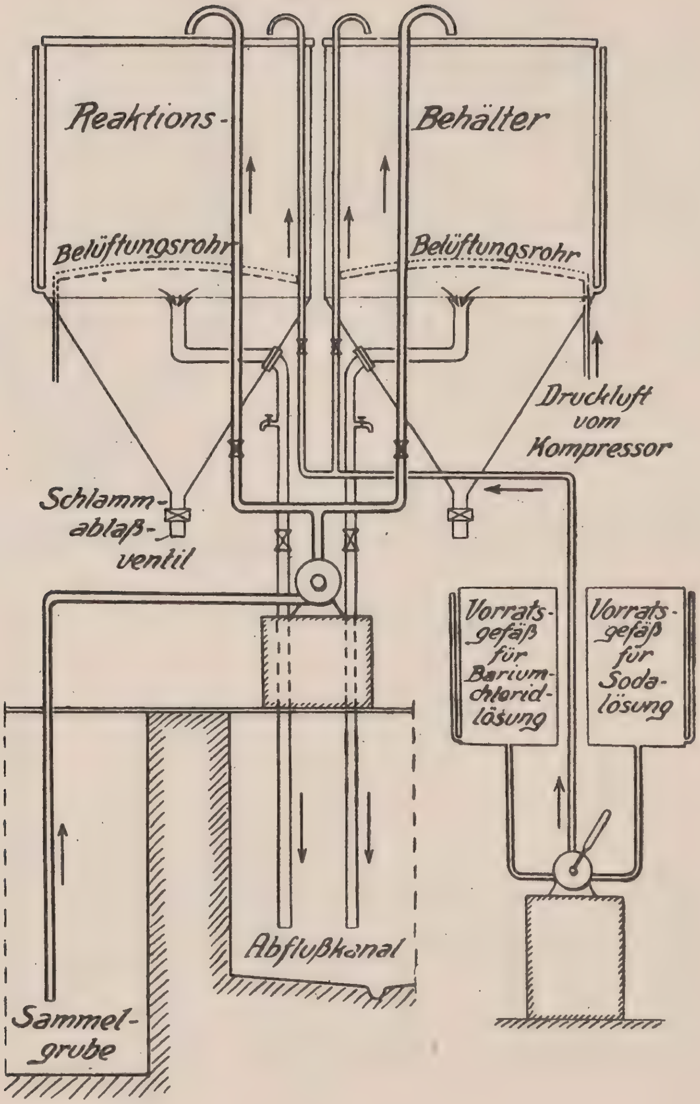

Fig. C-1-c, Chromate Waste Treatment
Flow Sheet

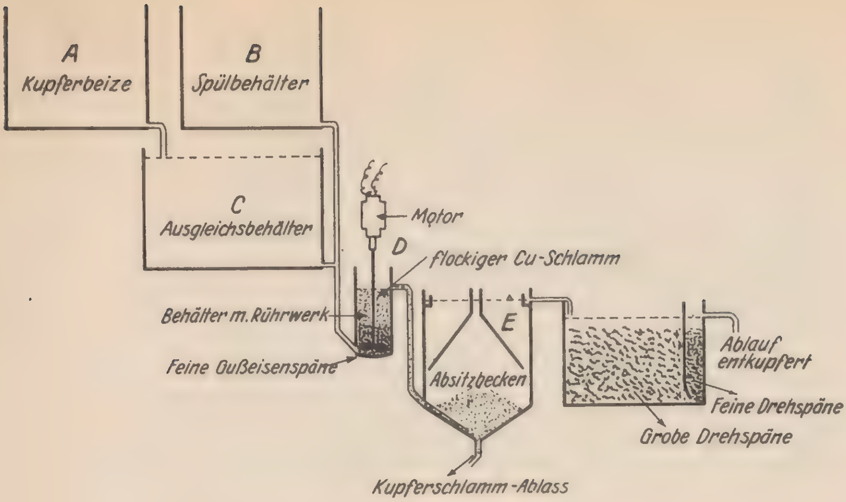

Fig. C-2-a, Copper Waste Treatment Process (Sierp)

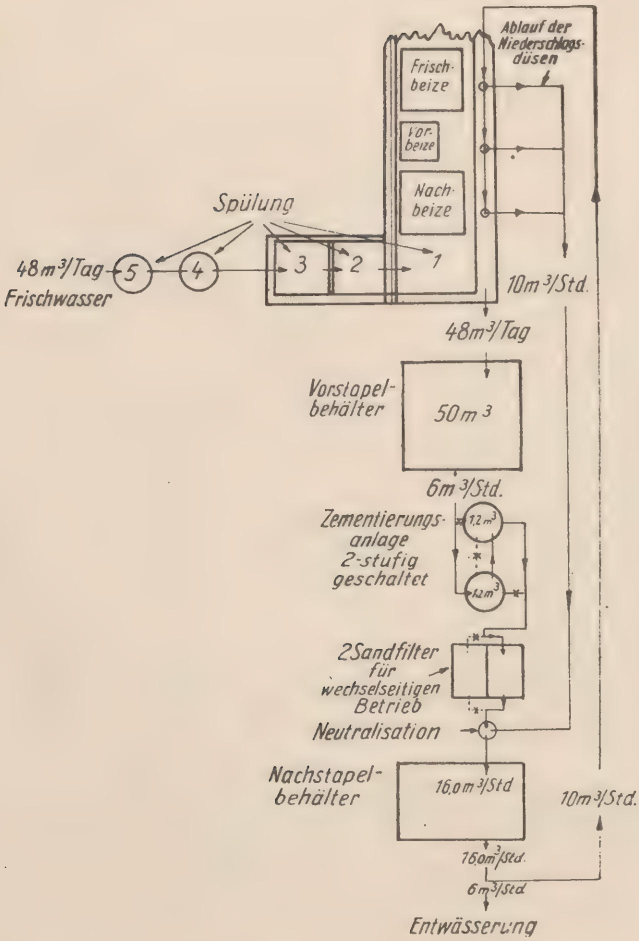

Fig. C-2-b, Copper Waste Treatment Small Plant Layout

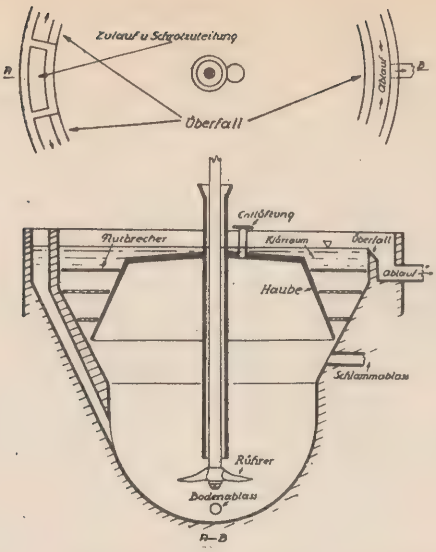

Fig. C-2-c, Copper Waste Treatment
Mixing Tank

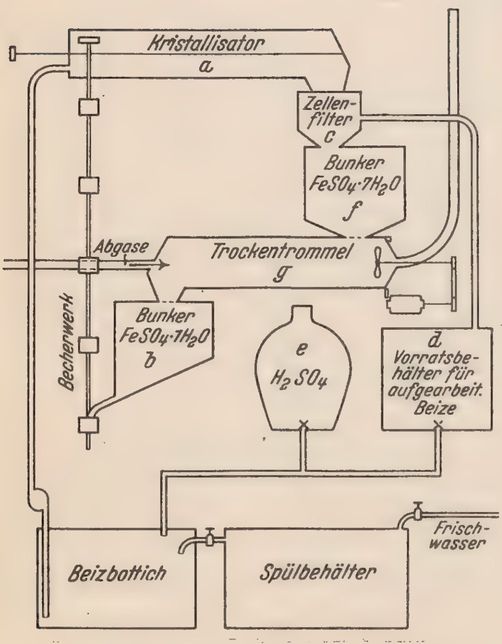

Fig. C-2-d, Pickling Waste
Treatment (Sierp and
Fransemeier)

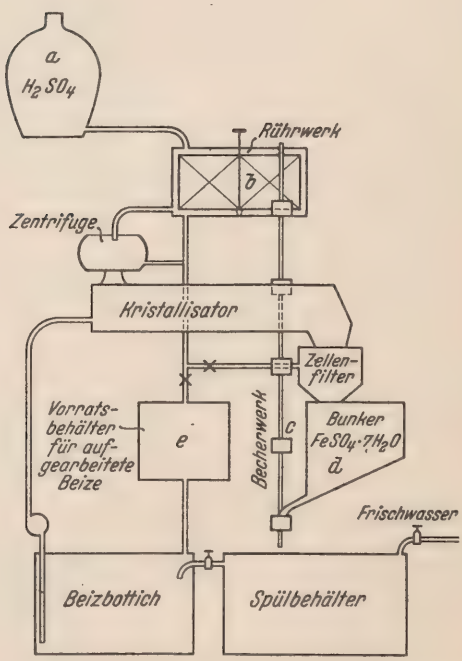

Fig. C-2-e, Pickling Waste
Treatment (Sierp and
Fransemeier)

Fig. C-3-a, Phenol Extraction Plant Using Benzol (Essen)

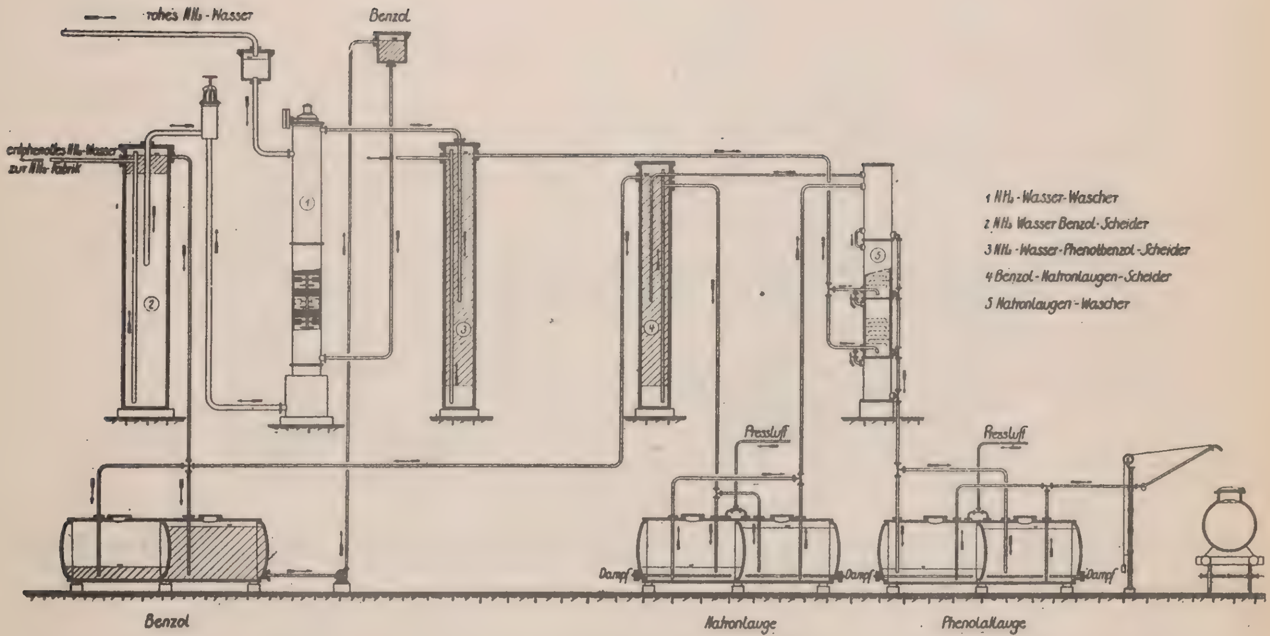

Fig. C-3-b, Phenol Extraction Flow Sheet (Benzol Method)

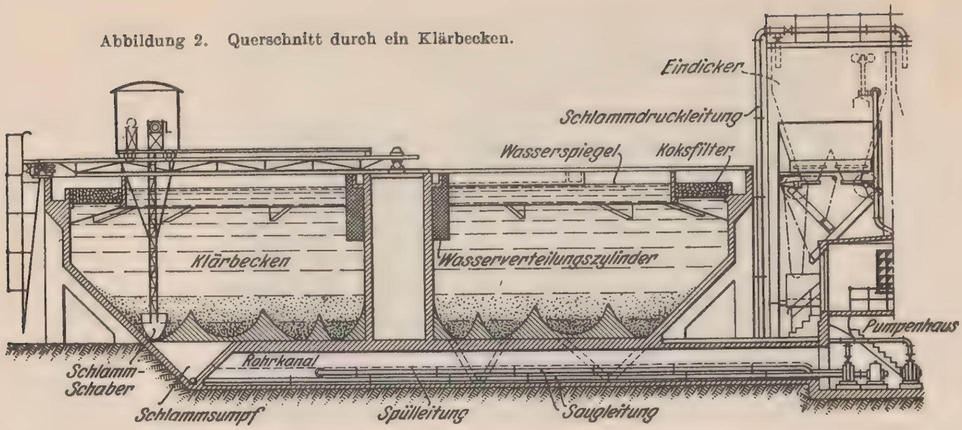

Fig. C-4-a, Coke Washing Plant. Clarification Unit.

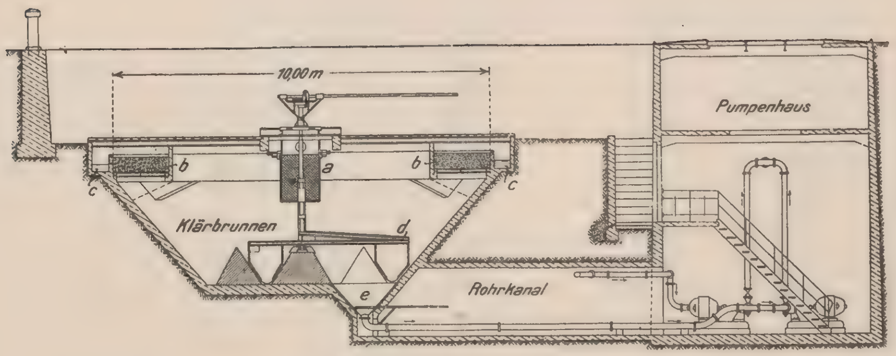

Fig. C-4-b, Coke Washing Plant. Clarification Unit.

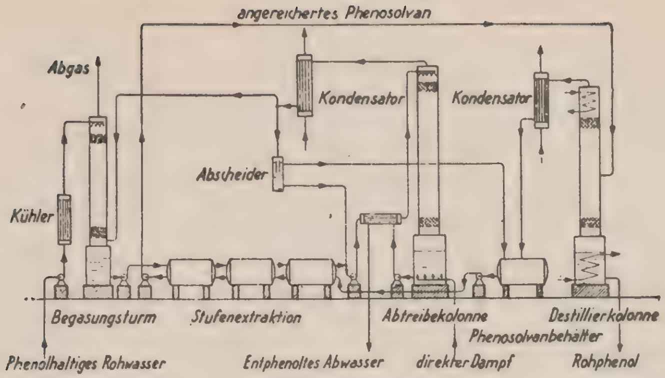

Fig. C-5-a, Phenolsolvan Flow Sheet

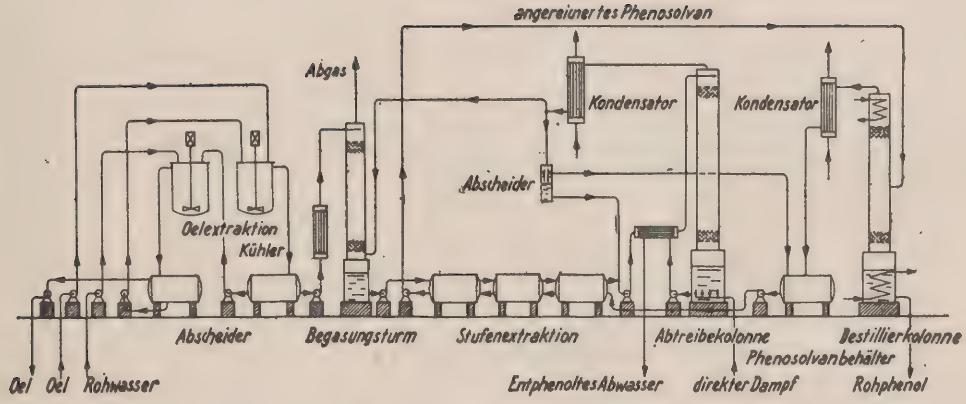

Figure C-5-b, Phenolsolvan Flow Sheet

FIAT FINAL REPORT NO. 96

UNCLASSIFIED

WATER SUPPLY, SEWAGE, AND INDUSTRIAL WASTE TREATMENT

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